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ABSTRACT

The purposes of this study were to determine if single language instruction was more efficacious than bilingual instruction in a science context and to investigate the transfer of learning science content and process skills from one language to another. Fifth-grade children from four schools in New Mexico who had had bilingual education for at least four years were randomly assigned to one of four treatment groups, and were instructed in subordinate and superordinate units of science. Three dependent measures were administered. Two measures sampled student performance in science activities; one was administered after initial science instruction, the other at the completion of the study. Measures were also administered for student language preference and attitude toward science instruction. The major finding of the study was that there were no significant differences between treatment groups receiving instruction bilingually and those having single language instruction. The students receiving total instruction in English did no better on the dependent measures than those students receiving total instruction in Spanish, and students receiving instruction in both Spanish and English performed just as well as those instructed in a single language. The students showed a statistical preference for a bilingual environment as opposed to a monolingual environment. (Author/MLH)

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SUBORDINATE AND SUPERORDINATE SCIENCE PROCESS SKILLS: AN EXPERIMENT IN SCIENCE INSTRUCTION USING THE ENGLISH AND SPANISH LANGUAGE WITH FIFTH GRADE CHILDREN IN BILINGUAL SCHOOLS

by

JOHN R. JUAREZ

A dissertation submitted in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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1975

Approved by Roger D. Olstad
(Chairman of Supervisory Committee)

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Abstract

SUBORDINATE AND SUPERORDINATE SCIENCE PROCESS SKILLS: AN EXPERIMENT IN SCIENCE INSTRUCTION USING THE ENGLISH AND SPANISH LANGUAGE WITH FIFTH GRADE CHILDREN IN BILINGUAL SCHOOLS

By John R. Juarez

Chairman of Supervisory Committee: Professor Roger G. Olstad
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The purpose of this study was to determine if single language instruction was any more efficacious than bilingual instruction in a science context. A main concern of the study was to investigate the transfer of learning science content and process skills from one language to another. Additionally, information was sought on the students' reaction to bilingual science instruction.

The study involved 104 fifth grade children from four different schools in New Mexico that had had bilingual education for at least four years prior to the study. The students were randomly assigned to one of four treatment groups at each of the four schools. The four treatment groups were instructed in subordinate and superordinate units of science.

Prior to instruction all teachers were trained in the use and presentation of selected science units.

Three dependent measures were administered to the students. The first dependent measure sampled the student performance in initial science instruction. This measure was administered immediately after science instruction in the subordinate science activities, and each child took the individual competency measure. The student was required to score correctly on at least 80 percent of the measure to meet criterion. The second dependent measure sampled the student performance on the final set of science activities. This measure was also administered individually. The third dependent measure was administered to all students to measure student language preference and attitude toward science instruction.

Alpha was set at .05 to test the following hypotheses:

1. Bilingual children instructed in Spanish will learn science content and process skills as well as bilingual children instructed in English, but neither group will learn the content and process skills as well as students instructed bilingually in Spanish and English when science activities are presented in a subordinate and superordinate order.

2. Bilingual children receiving science instruction will demonstrate a preference for instruction in two languages (Spanish and English) rather than instruction in a single language.

The major finding of the study was that there was no significant difference between treatment groups receiving instruction bilingually and those having single language instruction. The

students receiving total instruction in English did no better on the dependent measures than those students receiving total instruction in Spanish, and students receiving instruction in both Spanish and English performed just as well as those instructed in a single language. The students showed a statistical preference for a bilingual environment as opposed to a monolingual environment. This was significant at the .05 level.

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Chapter 1

INTRODUCTION

The topic of bilingualism has been studied extensively; however, bilingual education in the United States has been a puzzling but little studied topic in the research arena. Bilingualism and bilingual education are not the exclusive domain of the psychologist, sociolinguist, or psycholinguist, but are also topics that have caused increasing concern for educators.

Educators, today and in the future, have the task of educating a heterogeneous population that in many instances have limited English speaking ability or speak a language other than English. It has been estimated that there are over five million school children in the United States who have English as a second language (USOE, 1975). An examination of United States educational history indicates that, at one time or another, the schools have felt the inadequacies of trying to promote quality education within a populace that is ethnically, racially, or culturally different (Andersson and Boyer, 1970). In overview, with regard to bilingual education in various states, it seems that the problems of bilingual students have not been clearly articulated and have been treated more as isolated incidents to the larger problems of education for the dominant group.

POLICY DEVELOPMENT IN BILINGUAL EDUCATION

On January 2, 1968, the Elementary and Secondary Education Act of 1965 was formally amended to include Title VII, the Bilingual Education Act. Since that time the federal government has declared itself an active participant in bilingual education. Prior to this, there had been some isolated efforts in bilingual education, but not until the Florida school systems felt the full impact of the Cuban refugees was bilingual education for the Spanish speaking considered in earnest (Civil Rights Digest, 1974). The Mexican-American/Chicano* had asked for many years that the subject of bilingual instruction be given consideration. George I. Sanchez (1951) wrote about his concerns regarding the education of Chicanos and the various aspects of their segregation: legally, educationally, and morally. Presently, while federal monies have reached only a very small percentage of the total school districts that have qualified bilingual students,

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*"The term 'Mexican American' refers to persons who were born in Mexico and now hold United States citizenship or whose parents or more remote ancestors immigrated to the United States from Mexico. It also refers to persons who trace their lineage to Hispanic or IndoHispanic forbears who resided within Spanish or Mexican territory that is now part of the Southwestern United States.

'Chicano' is another term used to identify members of the Mexican American community in the Southwest. In recent years it has gained a wide acceptance among many persons of Mexican ancestry and reflects a group identity and pride in Mexican culture and heritage. In this report 'Chicano' and 'Mexican American' are used interchangeably." Report VI: Mexican American Education Study - A Report of the U. S. Commission on Civil Rights, Washington, D.C.: U.S. Printing Office, February, 1974. (Likewise, in this dissertation, the terms are used interchangeably.)

strong support from states has been rather slow in developing. For example, Article XII, Section 8 of the Constitution of the State of New Mexico provides for the training of teachers in both Spanish and English to instruct the bilingual populace. Section 10 of that same Article protects the equal right of education for Chicano children. The New Mexico Constitution was adopted January 21, 1911, and it is the opinion of this researcher that little has been done in the interim to enforce the Constitutional mandate. Massachusetts, in 1972, required bilingual instruction for non-English-speaking children and Texas began the 1974-75 academic year with the introduction of bilingual education (Civil Rights Digest, 1974). Many of the recent developments in bilingual education have received impetus from various court rulings (Lau v. Nichols) (Serna v. Portales) under the fourteenth Amendment and the Civil Rights Act of 1964.

BILINGUAL EDUCATION IN PERSPECTIVE

With respect to the history of education in the United States, there have been many educational experiments and theories that have failed, and bilingual-bicultural education is just as susceptible to many of the same failings that take a toll of other educational innovations. Furthermore, bilingual education has not been without its detractors and there have been several arguments against it. Many persons considered bilingual education un-American, not needed, of no economic benefit, or as a remedial program for children who have some learning disability. One by

one the barriers have been removed. Nonetheless, there are still many who are not convinced that bilingual education is legitimate instruction.

Most educators involved in bilingual-bicultural education are no longer concerned with developing an underlying rationale for such instruction. An abundance of research supports the concept of instruction in the first language of the child (UNESCO, 1953) (Modiano, 1968) (Moore, 1972) (Ervin-Tripp, 1973). Educators are now at the point of asking questions such as: Is bilingual education working? Can the gains in bilingual education be measured? Can bilingual education be expanded to include secondary as well as elementary grades? What are the variables that one must isolate to evaluate bilingual programs?

BILINGUAL EDUCATION--ASSUMPTIONS OF LANGUAGE AND COGNITION

In bilingual education the relationship of language and intellectual development with regard to psychology, psycholinguistics, and bilingualism is important. Psycholinguistics is

> ...interested in the underlying knowledge and abilities which people must have in order to use language and in order to learn to use language in childhood. ..."underlying knowledge and abilities" because language, like all systems of human knowledge, can only be inferred from the careful study of overt behavior. (Slobin, 1971)

Developmental psychologists from the Piagetian school feel that language is not essential for intellectual development. Language can facilitate or organize experiences but language is of

secondary importance in cognitive development since sensorimotor schemata occur earlier (Ginsburg and Opper, 1969). Cognitive development takes a natural course with respect to the environment. However, Bruner (1966) pointed out that the instructional environment has more to do with intellectual development than an environment relatively free of a structured plan for intellectual growth: Language being a major pathway to this end. It is through language development that the child frees himself from concrete situations to more perceptive and abstract elaborations.

Piaget's notion of cognitive growth seems at first to put him in direct opposition to exponents of bilingual education. Inhelder et. al. (1966) held that linguistic training proved of little worth in facilitating intellectual development and that the postulated sequence of cognitive development by Piaget was consistent with their findings. Slobin (1971) commented that "The general findings (Inhelder, et. al.) have been that special linguistic training will be of no avail to a child unless his level of cognitive development has already reached the point at which it can embrace the relevant concepts represented by the words." The training described was in relationship to Piagetian conservation tasks. Flavell and Hill (1969), Brainerd and Allen (1971), and Glaser and Resnick (1972) reviewed and reported highly successful training experiments in the Piagetian tasks which contradicted Inhelder's earlier findings. Bruner (1964) had earlier theorized that it was the highly suggestive visual

influences that caused cognitive dissonance, and that language training could act as a mediating device.

Language is culture specific and rapidly develops in a reinforcing environment. The reality of the world is filtered through the child's culture and environment. While Vygotsky (1962) and Piaget (1974) differ in the relative importance assigned to language, they do agree that language is developmental in nature; developmental in the sense of culture and environmental influences. Vygotsky (1962) points to two methods by which a language influences concept development; the scientific concept, a language-influenced intervention development such as in the schools, and spontaneous concepts developed in the home or natural environment. Slobin (1971) in discussing Bruner's later work concerning five sources of language-influenced intellectual development quoted Bruner as follows:

> (1) Words can serve as "invitations to form concepts." That is, the very occurrence of unfamiliar words stimulates the child to discover the meanings of those words. (2) Dialogue between adult and child can serve to orient and educate the child, providing an important source of experience and knowledge. (3) School creates the need for new uses of language--particularly context-free and elaborated uses. (4) Scientific concepts are developed in a culture and are conveyed verbally. (5) The occurrence of conflict between modes of representation can be a source of intellectual development.
>
> These five aspects of language use in cognitive development vary with culture and social class, interact with one another and can influence intelligence in many ways.

While evidence is still being accumulated, trends indicate that language does play an important part in human behavior and the way humans develop intellectually.

Bilingual education is based on the premise that fluency in language is important in learning. If teaching is done in the language in which the child is fluent, the learning will be more adequate than if the teaching is done in the language in which the child is less fluent. As Luria (1959) stated, "Human mental activity takes place in conditions of actual communication with the environment, in the course of which the child acquires from adults the experience of many generations." If one accepts Piaget's concept of language development, the second language introduces a symbol variable which confounds and complicates the issue, especially if the child still maintains a centering schema or structure. In addition, the bilingual child up to the point of logical operations must reconcile ego-centric meaning with his cultural meaning plus second language syntax and meaning. By using the language that the child is most familiar with, the child is not penalized by having to develop fluency in the second language. Further developing a bilingual fluency does not handicap growth in the child's cognitive and psychomotor development (Peal and Lambert, 1962) (Valencia, 1972). It is then expected that, after a period of time, there will be equal facility in learning via both languages regardless of subject matter or content (Valencia, 1972). Andersson and Boyer (1970) stated: "This is the essence of bilingual-bicultural education: not to block the child's learning by accidental limits imposed by any one culture or its language."

THE PROBLEM IN BRIEF

Much of the teaching enterprise involves practice and repetition. However, caution must be exercised in the use of repetition, particularly in a bilingual class where there is a great tendency to translate the lesson verbatim into the second language. Several serious consequences might result from this situation: teacher time might be expended on priority subjects not allowing enrichment in other disciplines, e.g., science; children might cover less material; and, most importantly, the situation might result in a challenge to one of the basic assumptions of bilingual education, that of transfer of learning across languages. Additionally, Andersson and Boyer (1970) suggested that:

> ...translation or near-translation involves three major hazards in a bilingual problem if the same child gets both versions. First, it is boring. Hardly anything more damaging could be said about elementary school instruction. Only the most phenomenal child will learn from something that bores him. Second, if the child knows he will get the same thing sooner or later in his own best language, he will tend to wait for that, and not reach for the second language. And third, materials that are translated for this purpose are almost invariably unicultural in content.

There have been few experimental or descriptive studies to confirm or reject the above statements (Peal and Lambert, 1962) (Trevino, 1968). Teacher training at various institutions of higher education introduced students to various types of bilingual models and pedagogical techniques. While the undergraduates are experiencing bilingual-bicultural teacher training, there is still some uncertainty as to the transfer of learning from one language

to another. The issue is debatable. One of the principle intents of this study was to add some needed information to the area of transfer of learning from one language to another in the context of a discipline, science in this case. A second, and important intent of this study was to address itself to the question of whether bilingual instruction had any more significant value than single language instruction in terms of learning when the content was unicultural science material.

Chapter 2

REVIEW OF RELATED LITERATURE

The review of literature in this study is comprised of four major components relating to the instruction of bilingual children. These components are (a) transfer with regard to subordinate and superordinate process skills, (b) language acquisition and development, (c) assessment of learning potential, and (d) bilingual science instruction. As much as possible these topics have been examined, especially as they relate to the Chicano child and to elementary school science.

> Recent work on children's language acquisition has brought out strongly that the child is not just a passive vessel of sense impressions. He actively strains, filters, reorganizes what he is exposed to. His imitations are not exact duplications or even random reductions of input but reflect knowledge similar to that revealed in his other uses of language. In this respect, first and second language learning must be quite alike. The learner actively reorganizes, makes generalizations, simplifies. (Monograph No. 23, The Report of the Twenty-First Annual Round Table Meeting on Languages and Linguistics, 1970)

TRANSFER OF LEARNING

Perspectives on Transfer

There is a psychological issue that revolves around the notion of transfer of learning or training. The issue stems primarily from the different attributes assigned to the transfer of learning or training. Since the early part of the nineteenth century and up until the present, the concept of transfer of learning has occupied a rather prominent role in research.

Formal discipline, the process of exercising the mind by learning difficult subjects, was once considered the best vehicle for general transfer. In what are considered classical studies, Thorndike and Woodworth (1901) found little correlation between the difficulty of school subjects and mental abilities in a sample of over 13,000 children.

Judd (1908) developed a generalization theory of transfer. In his experiments, Judd took fifth and sixth grade boys, equated them, and split them into experimental and control groups. He explained the principle of refraction to the experimental group, while the control group received no explanations and were left to discover the nature of refraction by experience. Both groups were allowed to throw darts at a target that was submerged in twelve inches of water. There was no appreciable difference between control and experimental groups with regard to success. However, when the depth of the water was altered to four inches the control group performance fell markedly. The experimental group made the proper adjustments and were significantly more successful.

Thorndike (1914) on the other hand, utilizing his earlier experiences in studies with Woodworth, formulated a theory which accounted for some of Judd's observations. Thorndike considered transfer to take place most effectively when "identical elements" were involved. Thorndike's experiment called for training subjects to a high degree in estimating areas of rectangles, lengths of lines, weight of objects, and marking parts of written speech. The findings of the study gave indication that training had a positive

effect and that transfer was greater when the similarity of the tasks had a positive correlation.

The studies mentioned provide an historical perspective, but are only a sample of the number of experiments that began to accummulate. Orata (1935) reviewed some 167 experiments on transfer of which he concluded 76 percent to be successful. The studies are too varied to give details here, but Trow (1958) commented:

> In the hundreds of researches that have been conducted in transfer of training, three definite conclusions recur again and again. The first is that intelligence is positively correlated with transfer. The second conclusion is that in general the more nearly similar the tasks the greater the transfer. The third clear conclusion from the experiments is that methods of learning and instruction are of prime importance.

Transfer is not as clear-cut as it may appear to be. It varies along with variations in learning theory. As Shulman (1968) indicated, available literature had not resolved the issue of transfer of learning, especially as it applies to any psychology of learning.

A prime issue in the transfer controversy is the question of how the different proponents of learning define transfer. It is not easy to discuss transfer, in relation to competing theories of learning, when in fact the operational definitions given transfer are not compatible. They are not compatible in the sense that the concept of transfer is one of the central concepts of all psychological theories of learning. This becomes even more significant when learning theorists cannot agree on basic educational issues.

For example, Shulman (1968) briefly examined the positions of Gagne and Bruner in terms of instructional objectives, instructional styles, readiness, and transfer, and points to their differences as follows:

> The positions of Bruner and Gagne take very different points of view with respect to the objectives of education. This is one of the major reasons why most attempts at evaluating the relative effectiveness of these two approaches have come to naught. They really cannot agree on the same set of objectives. Any attempt to ask which is better--Michigan State's football team or the Chicago White Sox--will never succeed. The criteria for success are different, and it would be absurd to have them both on the same field competing against each other.
>
> ...let it be noted that when two conflicting approaches seek such contrasting objectives, the conduct of comparative educational studies becomes extremely difficult. (Shulman, 1968)

To resolve which psychological theory of learning best accounts for the phenomenon of transfer would be a monumental task and well beyond the scope and intents of this study. The issue is recognized, however, in order to show the need for any study on transfer to make clear the psychological theory which underlies it. In the case of this study the underlying theory of learning is the cognitive theory which will be briefly defined in the following section.

The Cognitive Position and Transfer

As it was already indicated, the various ways psychologists observe and categorize human behavior is not exactly consistent from psychologist to psychologist. In order to define the cognitive position, let us look at how Ausubel (1966) differentiated

it from the neo-behaviorist position. According to Ausubel, the neo-behaviorists are concerned with observable learned behaviors such as those which manifest themselves in stimulus-response and in environmental conditions which influence those behaviors. The neo-behaviorists are reluctant to address the notion of consciousness which cannot be reliably observed. They believe that only by observing categorizable behaviors can general scientific statements be made regarding behavior. The cognitive psychologists, on the other hand, (again, according to Ausubel) assume quite the opposite and feel that by examination of the different states of consciousness more appropriate statements regarding human functioning and underlying cognitive process can be made.

Ausubel classified Bruner, Gagne, and himself as cognitive psychologists. However, Ausubel stated that both Bruner's and Gagne's position on transfer differ from that of his own as follows:

> This difference stems in part from their somewhat more behavioristic conception of the nature of knowledge as consisting of the capability of performing different classes of problem-solving tasks. Thus, in fostering transfer, Gagne focuses on the learner's possession of the component or subordinate problem-solving capabilities required for manifesting a g ven higher-order problem-solving capability. Concentrating more on the deductive aspects of transfer, Bruner emphasizes "generic learning" because it can facilitate derivative problem-solving, that is, the solution of problems that are particular exemplars of a more general proposition. Ausubel on the other hand, views knowledge as a substantive (ideational) phenomenon rather than as a problem-solving capability, and regards transfer functions of cognitive structure as applying more significantly to reception learning than to problem-solving in the typical classroom situation. (Ausubel, 1966)

Thus, even within a particular psychology of learning such as that of the cognitive theorist, there are many interpretations as to the significance and methods of transfer. This necessitates even more specific identification of the learning theory this study reflects. The specific theory is that of Gagne.

Gagne's Cummulative Model for the Transfer of Learning

Gagne (1962) developed the cummulative model for transfer of learning. It is a hierarchial scheme for transfer and resembles some earlier studies of Maltzman (1955) and Harlow (1949). The model is constructed of several sequences of subordinate and superordinate skills that are the results of task analysis. The subordinate and superordinate process skills will be discussed jointly with Gagne's concept of transfer because they are the essential elements of the model.

Gagne, in his work on programmed learning, based some of the important aspects of his theory on task analysis and cummulative learning, as a model for specific transfer, on his research findings (Gagne and Brown, 1961). One of his studies evaluated the performance of seven ninth grade boys on a series of mathematics tasks relating to a final activity of finding the sum of n terms in a number series. The final task was identified and then a systematic breakdown of the subordinate tasks required to achieve the final task was accomplished by continually asking what the student must know and be able to do before he can accomplish a particular task. Employing the method of task

analysis, nine subordinate tasks, arranged in a hierarchial order, were identified.

Gagne stated that there are two important variables for which one must account in a model such as the one he postulated. These two variables were knowledge and instruction. Knowledge was defined as the capabilities that an individual possesses at any stage. Instruction consisted of the following components: (a) recognizing and acknowledging the required final task, (b) identifying the elements of the task, (c) receiving practice and repetition to insure recall, and (c) being guided by one's thinking. Gagne further stated that positive transfer depended on "(a) the recall of relevant subordinate learning sets, and upon (b) the effects of instruction." (Gagne and Brown, 1961)

In the experiment, students were tested on a series of tasks in mathematics until they reached a point of being unsuccessful. An individual instructional program was then set up to foster achievement at the next higher level of the series of nine tasks. Gagne's success rate with the experimental group averaged 86 percent. He interpreted the results as positive evidence of the knowledge hierarchy. One of the overall conclusions was that if a subject passed a higher level task no lower task was failed. Gagne stressed that individual differences may have accounted for less than 100 percent success in his experiment and that a model of transfer such as the one he conceived needed to take into consideration these individual differences as an important variable.

In an associated work, Gagne and Smith (1962) pointed to the importance of not only knowing what are the expected terminal behaviors in a problem-solving situation, but the ability to formulate the terminal task and subordinate elements in the subject's own words.

Gagne and Smith, working with twenty-eight ninth grade boys, investigated two suppositions: The first was to find if problem-solving was facilitated or interfered with when a subject was required to verbalize a discovered principle (solution set) related to a particular task. The second was to investigate if differences in performance were the result of the effect of instruction which included verbal descriptions of a discovered principle.

The twenty-eight boys were distributed into four treatment groups: (a) Verbalizing, Solution Set; (b) Verbalizing, No Solution Set; (c) No Verbalizing, Solution Set; (d) No Verbalizing, No Solution Set. The task for the experimental groups was to move a set of discs from one circle to another circle in the least number of possible moves, maintaining the same size order of the discs.

The verbalizing groups out-performed those subjects not required to verbalize their moves. Gagne felt that the act of verbalization caused reflective and creative thinking, thus accounting for the better performance of the verbalizing groups. If this conclusion is accepted, then it would seem to this researcher that the student who has a language preference would

certainly be at a disadvantage unless the student is given the opportunity of utilizing his preference language. On the other hand, if a bilingual student has a language preference, it may lead him to be more verbal in one language.

For the bilingual situation, this work of Gagne is subject to many interpretations. It is the opinion of this investigator that the study builds a good case for the student who is bilingual and might prefer to verbalize in one of two languages. In a bilingual school environment, the student would have several opportunities to express his preferred learning style.

In this study Science--A Process Approach (1968) was used as the model for transfer, which is consistent with Gagne's model. Science--A Process Approach reflects the cummulative model for transfer of learning described by Gagne (1968) and it is his operational definition of transfer that was used in this study:

> Cummulative learning thus assumes a built-in capacity for transfer. Transfer occurs because of the occurrence of specific identical (or highly similar) elements within developmental sequences. Of course "elements" here means rules, concepts, or any of other learned capabilities.

In addition, Gagne (1965) (1962) clarified the hierarchial scheme of subordinate and superordinate skills in his hypothesis:

> (a) no individual could perform the first task without having those subordinate capabilities (i.e., without being able to perform the simpler and more general tasks), and (b) that any superordinate task in the hierarchy could be performed by an individual provided suitable instructions were given, and provided the relevant subordinate knowledges could be recalled by him.

One of the crucial tests of Gagne's model was the assessment of Science--A Process Approach. This was especially significant

because the research data was accumulated from various test sites through the country which reflected not only rural, suburban, and urban children but also the different social and economic conditions of children from kindergarten through sixth grade. Walbesser (1965) designed the model for evaluation and the hypothesis to be tested was stated as follows:

> If behavioral objectives are stated, instructional activities written for guiding the teacher based upon the stated objectives, and behavioral hierarchies constructed from the stated objectives, then the percentage acquisition of the stated behaviors by the learners will be the same for all socioeconomic levels. (Walbesser and Carter, 1968)

The data supported the hypothesis, but there was a socioeconomic effect. All process skills were investigated and it was found that disadvantaged children tend to perform better in the skills of Observing and Classifying than in the Numbers and Communicating processes. It was reported that verbal fluency may have effected the acquisition of certain behavior skills. Nonetheless, Gagne's model of cummulative learning proved to be quite successful with respect to transfer.

In employing Gagne's model of cummulative learning in this study it was assumed that his model of transfer of learning, as depicted by Science--A Process Approach, would be the most useful of the several elementary science projects to generate the desired behavioral data on transfer to match the transfer assumption of bilingual education. In reviewing major elementary science projects, the investigator found that Science--A Process Approach had built-in instruments to sample the skills and competencies acquired by the student. By use of a binomial scale on a dependent

measure, behavioral data can be obtained for analyzing transfer. Ramsey and Howe (1969) pointed out that of the elementary science projects, Science--A Process Approach, at that time, was the only major project that had an evaluation design to substantiate its model for learning.

While there is no conclusive evidence to state whether Gagne's model accounts for the transfer of learning better than other models for transfer of learning, his model is successful in producing the desired effects of his definition of transfer (Shulman, 1968).

It was not the intent of this review to resolve the issue of transfer of learning. The investigator, for the purpose of the study, accepted the operational definition of transfer as stated by Gagne (1968). This review centered on describing some aspects of the Chicano child as a student, keeping in mind Shulman's (1968) statement:

> Individual differences in learning styles are major determinants of the kinds of approaches that work best with different children. Yet this is something we have in general not taken into consideration at all in planning curricula--and for very good reasons. As yet, we do not have any really valid ways of measuring these styles. Once we do, we will have a powerful diagnostic tool. Subject matter, objectives, characteristics of children, and characteristics of the teacher are all involved in this educational decision.

Gagne (1962) expressed this same concern, and work by Ramirez and Castaneda (1974) with bilingual Chicano children showed promise in this area.

LANGUAGE ACQUISITION AND DEVELOPMENT

The development of the capacity to function in an open or a structured institutional environment poses certain problems for the bilingual child. This is so because the language that the child brings to the school may or may not be valued in terms of learning by the school. In addition, the facility with language may cover a broad spectrum of competencies of which the school may be ignorant.

> Bilingualism is an achievement that arrives by many routes. The bilingual-in-process might be a child growing up in a bilingual adult milieu, member of a bilingual family, or or a monolingual minority. He might be an adult who has moved to a different linguistic environment. The learning process might be casual or systematic pedagogy. The differences in what the learner hears, what he is expected to say and how much formal correctness is demanded from the start make for radical differences in the process of acquisition according to age and milieu. (Jones, 1973)

For the bilingual child as for other children, language is developmental, progressing from being highly dependent on concrete experiences to abstract socialized functions. Several research studies indicate that language at an early age is not only quantitatively but qualitatively different for the child as opposed to the adult (Piaget, 1974) (Vygotsky, 1962) (Ervin-Tripp, 1973). The spoken language of the child is learned in a social environment and as a consequence it may be expected that the learning of content is concommitantly affected (Ervin-Tripp, 1973). However, because the language is learned in a social environment, the amount of social support is crucial for further development. According to Jones (1973), "Social support appears

to be of greater importance to children than to adults." Social support in this context means:

> ...that the learner hears speech in several languages outside the classroom, either because he moves between two monolingual communities or because there are consistent rules governing alternations in a bilingual community. (Jones, 1973)

Many instances have been documented where children learn a language in a particular social environment in addition to that of their parents only to have language atrophy occur upon being removed from the language and social contact in which it was learned. Once the social support is absent, the extinction is rather rapid. Witness the case of students studying a foreign language in an academic atmosphere void of social support. This, however, is not the case for the Chicano. Depending on the social setting, the Chicano child might move through a spectrum of language settings during any one day. The child may speak only Spanish to his parents or grandparents, a mixture of Spanish and English with peers and English most often in school. There is social support for language development of the child. Nonetheless, the relative importance attached to the language is directly dependent on the dominant socioeconomic influence in the community. In Monograph No. 23, The Report of the Twenty-First Annual Round Table Meeting on Languages and Linguistics (1970) it was reported:

> If the root problems of Chicano children in our schools are social, rather than linguistic, we can expect that the comparable structure here would provide a fully bilingual program, as in Miami. Thus the Chicano children could see their own language respected as a medium of instruction and see Anglophones struggling to learn it as they learn English. It would not be surprising if in such fully bilingual programs

> they eventually learn school English better than children in schools where English is the sole medium of instruction--- even though they hear and speak less English in the course of the school day.

This postulate is partly supported by Douglas Muller (1974) in his six year evaluation of a bilingual program in New Mexico. It is also important to note that the relative value placed on the language is crucial for acquisition and retention. Labov (1965) indicated:

> Values play an important role in determining whether a given condition of social support will produce or sustain learning. At a gross level, beliefs about the ease or appropriateness of becoming bilingual may affect the probability of child or adult learning.

If there is social support and a high value placed on bilingualism then the only limiting factors are the opportunity to express talents and the individual's intellectual capacity.

ASSESSMENT OF LEARNING POTENTIAL

Much has been written about intelligence and its relationship to race and ethnicity (Palomares, 1965). And while many ethnic groups have been scrutinized by a battery of achievement and intelligence tests, the Chicano has borne the brunt of recriminations resulting from such testing. According to Report VI: Mexican American Education Study (U. S. Commission on Civil Rights, 1974), Chicanos have been disproportionately placed in classes for the mentally retarded on the basis of intelligence tests that do not measure the intelligence of Chicanos, by achievement tests that cannot accurately predict the achievement

levels of Chicanos and by diagnostic tests that are incapable of adequately expressing the underlying structure that constitutes the cognitive functioning of the Chicano. In addition, prevailing stereotypes held by the dominant society allow some ethnic groups to avoid the humiliation and intellectual insult forced on the Chicano.

That Chicanos posed a problem to the Anglo educational system has been recognized since both came into contact. The problems was recognized in the Treaty of Guadalupe Hidalgo of 1848 which ended armed hostilities between the United States of America and the United States of Mexico. Though the educational rights of the Chicano were protected by treaty, very little was done to compel states to adhere.

Early psychological studies, whether ill-intentioned or not, had the effect of laying the groundwork for segregation and subsequent search for cognitive defects in the Chicano child (Sanchez, 1974). Coers (1935) in a study for the purpose of bringing about the assimilation of Spanish-speaking children with the children for whom the school system was originally planned, assumed that teachers and administrators had come to realize the importance of knowing how the achievement of the "foreign" children compared with that of the children of other white stock. His findings were consistent with many studies to come later that indicated that the relative achievement of the Chicano group was greatest on the arithmetic computation test followed closely by the relative achievement on the spelling test. The Anglos

nonetheless out performed the Chicanos with the Chicanos performing poorest on language usage.

Lamb (1930) earlier had shown that Chicanos do better on tests of manual dexterity than Anglos. There were eight performance tests in which dexterity was important. Included in the tests was the Goodenough Draw-a-Man Test. The Chicano ranked highest in four of the tests and tied for superiority in another which led the investigator to conclude that certain racial groups develop early skill in manipulation greater than that of the average "American" child. No mention was made if there was a positive correlation between performance on the tests and intelligence or achievement; and if skills in manipulation are related to language development.

Later, Tireman (1951), who had been working with Chicano children in New Mexico since the early 1930s, showed in his studies of Chicano children through eight grades, that there was a continual strengthening of arithmetic reasoning and arithmetic fundamentals as the child progresses.

A trend had already begun to indicate that the Chicano performed better on tests that measure reasoning rather than those tests measuring verbal comprehension. The ability of the Chicano to perform better in arithmetic fundamentals was neither attributed to any one specific cognitive structure or advantage nor extrapolated to the notion that arithmetic functions and symbols are the precise language of science. A correlation of this type has yet to be conclusively indicated. However, the

nature of the tests themselves and their freedom from cultural bias began to be questioned by Chicanos (Sanchez, 1974) (Palomares, 1965).

The genesis of the question led Jensen (1961) to initiate his own studies relative to the intellectual and learning abilities of Chicanos. Using the California Test of Mental Maturity for matching purposes, he ran several IQ groups of Chicanos and Anglos through certain learning tasks. Jensen pointed out that high IQ's are very rare among the Chicanos as measured by the California Test of Mental Maturity. His learning tasks gave evidence of what Chicano educators had been saying, but had been unable to convince schools and other educational institutions--that tests such as the California Test of Mental Maturity may be able to distinguish and predict between low IQ and high IQ Anglos, but are inadequate instruments for Chicanos. Jensen's results showed that a significant number of Chicanos classified as slow learners actually are quite normal and performed in the learning tasks as well as the high IQ Chicanos and Anglos.

The question of cultural bias in tests of IQ and achievement gave vent to different pathways in search of a genetic component or an environmental casual relationship (Shockley, 1972) (Gage, 1972) in intelligence. Scattered evidence from other fields showed that children from different cultures and different language groups performed differently on problem solving tasks (Zimmerman and Rosenthal, 1972) (Bernal, 1971). It also became

increasingly clear that Chicano children are brought up to view the world and reality differently from their Anglo counterparts. Thus, their language and their value orientation results in a performance significantly different from the Anglo (Karadenes, 1971) (McAnany, 1971) (Engle, 1971) (Bongers, 1971) (Beman, 1972) (Kagan and Madsen, 1971). Jensen (1973) later wrote:

> Our test of...Mexican-Americans show they do rather poorly on the culture-loaded types of tests based on verbal skills and knowledge, but they do better on the culture fair test... that measure the ability to generalize, to distinguish differences and similarities, to see relationships and to solve problems. The tests measure reasoning power rather than specific bits of knowledge.

Killian (1971) concluded after a three year longitudinal study on Spanish-speaking children that there is no evidence of cognitive deficits save a problem with the English language in verbal comprehension. Roberts (1970) had earlier indicated that some of the same tests used in Killian's research are misused when they are used for identifying language development. Both studies were funded by the Office of Education.

Some sophisticated tests (e.g., WISC, Stanford-Binet Intelligence Test, ITPA, BV-M Gestalt Test) have been administered to Chicanos; they have participated willingly or unwillingly in some educational experiments. The results continue to show that there exists a common core of language, culture and cognition, and a dependency assigned to these results by society and its educational institutions. If one of the ends of society is a pluralistic existence and dignity in being different, then the idea must permeate that society including its educational

institutions. The idea must go directly to the nucleus of the school; its curriculum, the specific disciplines which contribute to that curriculum, and its instructional staff.

BILINGUAL INSTRUCTION--RELATIONSHIPS TO ELEMENTARY SCHOOL SCIENCE

Science education in the elementary and secondary school has made significant changes and advancement in the last ten to fifteen years. Some of the more important changes that have occurred are found in particular philosophies of education and have merged psychological theories of learning with broad scientific concepts and process skills. In a highly technical and scientific society, it is desirable and even mandatory that the citizenry be scientifically literate (NSTA, 1964). Children should understand themselves, their environments and how these interact. Bilingual education gives indications of being a very effective tool in developing desirable cognitive skills in science as well as developing the humanistic qualities important to the culturally different child.

Because of its nature, science has become a discipline that knows no national boundaries. Scientists are able to communicate ideas and experimental work and share a symbolic language that to a certain extent communicates across languages. The progress that has been made, and will continue to be made, is not the private domain of any one ethnic, religious, or national group, though there has been a tendency for particular groups to excel in science (Hardy, 1974).

Educators involved in bilingual-bicultural education have sought information and answers regarding the best methods and materials for implementation in bilingual programs. Often this decision is based on the availability of materials in the market place. This has been the case with materials developed for Chicano children and those exported to Latin American countries; for example, the Biological Science Curriculum Study materials.

Materials that have been especially designed to foster scientific concepts and process skills in the dominant culture have been used not principally for this reason with Chicano children, but to teach English language fluency. References are made to increased vocabulary, reading readiness, interaction with peer/teacher, pupil involvement, but little mention is ever made of performance in science (Scheffer, 1969) (John and Horner, 1971).

Science techniques and materials have proved effective in getting children involved in situations which lead to interaction without the added burden of learning to read a symbolic interpretation of reality stifling to their natural curiosity. One of the objectives of the new elementary science curricula has been to get children actively involved and to develop positive attitudes about science, but the emphasis remains on the science and that is the way the materials should be used. Additionally, the results of the translation of these materials are that they transmit the one-culture influence. The desirability of this transmission must be resolved by those involved in bilingual education. It is

possible, as was done in Toronto, Canada, with a mathematics program (Giles, 1969) (Andersson and Boyer, 1970) to split the time allocated to science and teach it as if it were two different subjects using two different languages. Teacher preparation and available materials play an important role (Ott, 1968) (Trevino, 1968) (Hernandez, 1974).

Few science educators have concerned themselves with bilingual education, yet there are indications from the literature that bilingual science education might be a most fruitful area for investigation (Raisner, et. al., 1967) (Walbesser and Carter, 1968) (Giddings, 1966) (Stevens, 1969) (Perales and Howard, 1969) (Jourdane, 1970) (Theiss, 1970) (Billeh and Pella, 1970). Of the studies cited, the common consensus was that apart from further investigations into the area of science education, that a systematic approach to science be used taking into account the students' development and the socio-linguistic environment of his home. Bolger (1967) recommended that bilingual science programs should be staffed by fluent Spanish speaking teachers and that bilingual science programs would be most successful with bilingual children who tend to use Spanish most frequently. Scattered evidence from related fields to science showed that children from different cultures and language groups perform better in bilingual situations (Castaneda, 1967) (Trevino, 1968) (Robinson, 1970). Whether the differences in performances can be attributed to chance, linguistic or cultural factors or pedagogical technique has not been fully resolved.

SUMMARY

The review of the literature pointed to several important issues in bilingual education. One, there is a need to clarify and state the concept of transfer of learning, based on some psychological theory of learning, as it applies to bilingual education. Because transfer is one of the principle assumptions of bilingual education, it is essential that the research began to identify the conditions for this phenomenon. Secondly, it should be recognized that any bilingual program must take into account the developmental nature of language and its relationship to cognition. Additionally, the diagnostic instruments in vogue are not wholly adequate for the requirements of bilingual programs. It is also necessary to dispel the notion that bilingual education is strictly a language learning experience per se; rather it is an experience that conveys concepts, processes and subject matter via language. And it is this last issue that becomes even more significant to the researcher because the topic of bilingual science education is of such recency that research on it is almost completely absent.

Chapter 3

THE DESIGN OF THE STUDY

INTRODUCTION

Valencia (1972), in describing one of four underlying principles of bilingual education, spoke of the "...use of the learner's native language to facilitate the learning process and avoid postponement of cognitive and psychomotor development." With regard to second language development and learning, he further stated:

> The moment for utilizing the second language in the learning scheme is dependent on individual readiness, the nature of the subject matter, and the learning activity. Furthermore, since reading and writing skills are closely related among the Indo-European language, a transfer effect will occur in developing such skills in the second language. (Underlining not in the original)

In support of this statement the noted Russian psychologist, L. S. Vygotsky (1962) concurred:

> Success in learning a foreign language is contingent on a certain degree of maturity in the native language. The child can transfer to the new language the system of meanings he already possesses on his own. The reverse is also true--a foreign language facilitates mastering the higher forms of the native language. The child learns to see his language as one particular system among many, to view its phenomena under more general categories, and this leads to awareness of his linguistic operations.

One of the purposes of this experiment was to investigate the postulated transfer effect. The second purpose of the investigation was to determine the efficacy of bilingual instruction, particularly with regard to science education. Andersson and

Boyer (1970) gave evidence that children instructed bilingually made measurable gains over comparable groups taught the same content but in one language. This evidence was not conclusive with respect to science education.

SETTING

State

The State of New Mexico was selected as the site for this study because of its history of bilingual-bicultural education in the elementary schools. The schools selected for the study were located in cities or towns with a population of 55,000 or less. There were four schools that participated in the study. The schools selected for the study were separated by as much as 400 miles. Two schools were located in the northern part of the state (Las Vegas) and two were located in the southern part of the state (Las Cruces). In general, schools in New Mexico and in the Southwest that have bilingual-bicultural education programs have a large number of Chicanos and the Chicanos are usually the dominant group in the bilingual classroom. In this study approximately 95 percent of the students were Chicano.

The development of bilingual education in New Mexico is comparatively recent within the larger framework of educational history in the state. Gonzalez (1969) pointed out that:

> New Mexico is the only state in the union which may be said to be effectively bilingual. This has repercussions in the school system, advertising media, court system, entertainment world, etc.

Unfortunately, the Spanish language is not taught in the elementary years, and this has resulted in its becoming a "second-class" language, passed on only imperfectly through the oral tradition alone.

The Spanish language influence came into the state between 1539-1583 with the Spanish expeditions of Coronado, Chamuscado and Rodriguez, and Espejo. Although there had been earlier expeditions and trade routes established through the towns of investigative interest, the Mesilla Valley (Las Cruces area) and the Las Vegas area were permanently occupied by Mexican and Spanish descendants between the years 1800-1840. It was from Las Vegas, New Mexico, that General Stephen W. Kearny in 1846 claimed New Mexico and the west bank of the Rio Grande for the United States.

Las Vegas. The consolidated town of Las Vegas, New Mexico, has a population estimated at over 14,000 by the 1970 census. The economics of the town and county (San Miguel) are dominated by agribusiness; the raising of livestock the major endeavor.

The county is 80 percent Spanish surnamed with many residents living in small rural villages around Las Vegas. The rural communities, while in most cases self-sustaining, are highly dependent on the town of Las Vegas for trade and commerce. The rural residents also depend on Las Vegas for the schooling of their children. The town has two school systems. When the two towns (East Las Vegas and West Las Vegas) were consolidated under one city government, it was agreed that the respective towns would retain their own school systems. The dual school system is not the only unique feature of Las Vegas as indicated by the following statement:

> Part of the community of Las Vegas (population 17,000), West Las Vegas is the poorer, older section peopled primarily by Mexican Americans who have resided there for generations. The town is in the northern, mountainous region of New Mexico, 60 miles from Santa Fe and 120 miles from Albuquerque. Las Vegas is the home of Highlands University (a small state-supported institution with 2,400 students), of a state hospital and a mental retardation facility. While a small group of white professionals are affiliated with these institutions, the vast majority of the labor force is Mexican American employed in construction, education (teachers, aides, clerks), hospitals and filling stations. Although housing is less costly than elsewhere, the modal income is only $5,600. (Leger, 1973)

West Las Vegas has had bilingual education in the elementary schools since 1970, and the vast majority of students that participate in the bilingual program are from low income families. The same is true for bilingual programs in East Las Vegas. For purposes of this study, a school was selected from each of the school systems in Las Vegas.

Las Cruces and Mesilla. Las Cruces is located in the southern part of the state. According to the 1970 census, it has a population in excess of 38,000. Related economics are tied to the government facility at White Sands Missle Range, the state agricultural school (New Mexico State University) and the building industry. Las Cruces is the county seat of Dona Ana County and the county has a strong agribusiness. While there are many small farms in the area, there are some large corporate run farms. The town is located some 45 miles from the larger metropolitan area of El Paso, Texas. Las Cruces and the surrounding area has a large Spanish surnamed populace and though many are involved in service oriented endeavors, the larger portion are involved directly or indirectly in agricultural related work.

Las Cruces has had bilingual education since 1967. The programs were concentrated at first in four schools and has expanded since. Two of the early schools involved in bilingual education were also included in this study. One school was located in Mesilla and one in Las Cruces proper. Most of the children participants come from families that have an income range of $3,000 to $5,000. The Spanish surnamed children dominate the bilingual classes with their percentage as high as 96 percent.

Relationships of Schools

To try to reduce the variability between schools, the investigator kept the instructional environment as physically similar as possible in terms of the schools selected for the study. Research on Science--A Process Approach (AAAS, 1968) showed that variances in instructional environment had little effect on performance of students. However, given the geographical locations of the schools in the study, one would expect that there would be an uncontrolled variability between schools. The investigator expected that a between-school variability would be evident in the final analysis. The homogeneity of subjects was maintained by random selection from a heterogeneous bilingual fifth grade class in each school. Demographic and socio-economic data available showed the students to be similar.

SCIENCE--A PROCESS APPROACH

Units from the American Association for the Advancement of Science's elementary curricular project, Science--A Process

Approach, were used in this investigation.

Overview of Curricular Developments

The national elementary science curricular projects place emphasis on the nature and structure of science and on the processes of scientific inquiry. The underlying theme of most projects is that it is important to develop within the populace a citizenry that is scientifically literate, to impart knowledge of how humans are in dynamic interaction with the environment, to develop the humanistic qualities necessary to live within a social milieu and to harbor deep respect for nature and the order of the natural world.

The new elementary science curricular projects stand in contrast to what has occurred in elementary science in the past and what occurs quite frequently today. That is, quite often the teaching of science in the elementary school is relegated to incidental ideas, to novel things as they come up or to the memorization of isolated facts. The national elementary science curricular projects believe that there is a more fruitful way for children to learn and appreciate science. These projects approach the matter of elementary science with a particular psychological theory of learning grounded in a philosophy of science and with a pedagogical system to reach the children.

Science--A Process Approach (1968 version)

Science--A Process Approach is one of the national elementary science curricular projects. The program had its inception at

Stanford University in 1963. The curricular package is broken up into seven Parts labeled A through G. Part A is the beginning unit and can approximate kindergarten on up, although this does not have to be the case. Each of the Parts consists of about twenty exercises. Each exercise deals with a set of processes and is color coded to distinguish the processes emphasized (AAAS, 1968). Parts A through D are primarily concerned with the development and acquisition of eight basic process skills: Observing, Using Space/Time Relationships, Using Numbers, Measuring, Classifying, Communication, Predicting and Inferring. Parts E through G concentrate on the integrated process skills which are more complex in nature and are identified as: Formulating Hypotheses, Controlling Variables, Interpreting Data, Defining Operationally and Experimenting.

As is evident from the title, the project stresses the development of process skills. Hurd and Gallagher (1968) described this process approach as follows:

> The processes of science represent its more stable elements since the methods giving rise to science changes less frequently than the concepts produced. Teaching the processes of science--its modes of inquiry--is providing young people with thinking tools that are not only applicable in the context of science but to life in general. What more, if children learn to use the processes of science, they will come closer to understanding the spirit of inquiry that characterizes science.

Robert Gagne (1965) further elaborated:

> The process skills are components of scientific inquiry, the procedures that give rise to knowledge and define its meaning. These procedures may be further subdivided into simpler skills, thus ultimately reducing the complex task of inquiry to a hierarchy of component processes.

The philosophy of Science--A Process Approach. Science--A Process Approach views the learner as a person that either has the requisite skills or does not in regard to mastering a certain class of tasks. It proceeds on the assumption that the learner can be guided through a hierarchial arrangement of tasks to mastery of those tasks if the sequencing of topics and the reoccurrence of the ideas are reintroduced in a proper manner.

The pedagogy of Science--A Process Approach. The principal pedagogical assumption of Science--A Process Approach is that the student must be actively engaged in the learning process. This means that the student will be involved in hands on activities. The students are encouraged, challenged and questioned when working with a particular unit of Science--A Process Approach. With the completion of a set of activities the students are expected, either in a group situation or individually, to demonstrate a minimum set of required behaviors. These are observable performances consistent with the completed activities and are known as Appraisal or Individual Competency Measure.

Materials. The materials that the students work with consider the intellectual development of the student and the materials are viewed with regard to the acquisition of intellectual skills (Hurd and Gallagher, 1968). They consist of prepackaged items referenced to the teacher's guide and are self-contained materials, save for consumable items.

The psychological basis of Science--A Process Approach. Science--A Process Approach is the most behaviorally oriented of the elementary science programs and is the most structured. Its psychology was influenced by Robert Gagne who saw the development of the process skills in a hierarchial order. Each idea is developed at its own requisite level and introduced as often (in different contexts) as necessary in conjunction with one or more ideas. Gagne saw differences in learning as dependent to a very large degree upon differences in previous learning; linking the learning of any scientific knowledge is dependent upon mastery of previous knowledge. This means the orderly sequencing of ideas and the learner knowing what learning goals are expected of him. Two things characterize Gagne's thinking in Science--A Process Approach: sequence of topics and practice. In sequencing of topics Gagne (1963) indicated:

> Knowledge is a hierarchy of ideas, in which the more complex ones depend for their acquisition on the previous mastery of simpler ones. Thus when a curriculum designer has in mind a set of ideas he wants students to acquire, he must ask himself very systematically, "What must the student already know how to do, in order that he can acquire this new knowledge?" The best way to construct the instructional sequence is to begin at the end and work backward with a rigorous application of this question at every step of the way.

Practice is a natural consequence to knowledge based on a hierarchy of ideas. Gagne believed that it is not only necessary for the learner to acquire the more complex ideas, but he must have a method of recalling simpler skills for true learning to take place. The best method of insuring that there is some permanence in developing this type of learning is practice and repetition.

Practice and repetition is not meant in the traditional sense, but taking previously learned ideas or processes and presenting them in new and novel situations necessary for the acquisition of new ideas. In reference to what was previously stated, Gagne defined ideas as "...an inferred capability of performing a class of tasks."

SUBORDINATE AND SUPERORDINATE SKILLS-- DEFINED FOR THE STUDY

Robert Gagne (1963) in describing knowledges (sic) that an individual should possess in developing generalizable behavioral skills in science, spoke of many subordinate skills. Knowledges carry the attributes of competency, skill and understanding. Gagne postulated four conditions regarding the serious pursuit of science and learning. In the four postulates the recurring concern was on building and developing subordinate skills to greater complexity. He stated:

> ...each subordinate knowledge is conceived of as building upon, and in a learning sense depending upon, all of the simple subordinate knowledges in the sequence, as well as some in other sequences. A progression of sequences has been postulated which make for a high probability of learning the next higher unit of basic knowledge, if the student has already mastered the related ones below; and for a low probability if he has not. (1963)

This investigator defined the development of the more complex skill superordinate to the subordinate skill.

HYPOTHESES

Research Hypotheses

The experiment was designed to investigate the following research hypotheses:

1. Bilingual children instructed in Spanish will learn science content and process skills as well as bilingual children instructed in English, but neither group will learn the content and process skills as well as students instructed bilingually in Spanish and English when science activities are presented in a subordinate and superordinate order.

2. Bilingual children receiving science instruction will demonstrate a preference for instruction in two languages (Spanish and English) rather than instruction in a single language.

Statistical Hypotheses

To test the research hypotheses the following statistical hypotheses were investigated:

1. Subjects experiencing instruction in Spanish will not perform significantly better on science competency measures than those subjects exposed to instruction in English when the scientific content is unicultural in nature.

2. Subjects experiencing instruction in English will not perform significantly better on science competency measures than those subjects exposed to bilingual (Spanish and English) instruction when the scientific content is unicultural in nature.

3. Subjects experiencing instruction in Spanish will not perform significantly better on science competency measures than those subjects exposed to bilingual (Spanish and English) instruction when the scientific content is unicultural in nature.

4. Considering all the subjects within the study without regard to treatment groups there will be no significant difference between the proportion of bilingual children preferring a bilingual approach to science instruction when compared with the proportion of bilingual children preferring monolingual science instruction.

DESIGN

To test the stated statistical hypotheses a 2 x 2 factorial design with complete replication was used to analyze the science competencies of bilingual subjects. Language was one of the independent variables and there were two levels* of this factor:* English and Spanish. Science content was the second independent variable and again there were two levels of this factor, the subordinate and superordinate science learning tasks. The dependent variables were two competency measures of science achievement and a language preference and attitude inventory.

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*Levels--"Many experiments are concerned with the influence of two or more independent variables, usually called factors, on a dependent variable. The number of ways in which a factor is varied is called the number of levels of the factor." (Edwards, 1968) When referring to the independent variables, this nomenclature will be followed.

There were four treatment** groups as can be seen in Figure 1. Treatment Group One was instructed in English only on both the subordinate and superordinate units of science instruction. Treatment Group Two received initial (first level) instruction in English and final (second level) instruction in Spanish. Treatment Group Three received initial instruction in Spanish and final instruction in English. Treatment Group Four received instruction in Spanish only on both the subordinate and superordinate units of science instruction.

Figure 1

Organization of Treatment Groups

Initial Instruction

Subordinate Science

Terminal Instruction Superordinate Science	English	Spanish
English	I Treatment Group English-English	III Treatment Group Spanish-English
Spanish	II Treatment Group English-Spanish	IV Treatment Group Spanish-Spanish

**Treatment--"With two or more factors each with two or more levels, a treatment consists of a combination of one level for each factor. When the treatments consist of all possible different combinations of one level from each factor...the experiment is described as a complete factorial experiment with equal replication." (Edwards, 1968) When referring to treatments or factorial designs this nomenclature will be followed.

There were a total of 104 subjects in the study randomly assigned with approximately equal numbers per treatment group (See Table 1).

Table 1

Distribution of Students in Treatment Groups

School	Number of Students per Treatment				
	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Total
School A	6	6	6	5	23
School B	6	6	7	7	26
School C	6	6	6	6	24
School D	7	8	8	8	31
Total	25	26	27	26	104

The treatment groups were drawn from a population of fifth grade pupils in four different schools. Though several school districts offered classrooms for the study, only those schools that had bilingual education through the fifth grade were selected. Also, the schools with the longest history of bilingual education through the fifth grade were selected as opposed to those schools with relatively new experience in bilingual education in the upper elementary grades. Thus, four schools were selected for the study and the fifth grade bilingual students within each of those schools made up the population of investigative interest. When the classrooms were selected, the teachers in those classrooms were selected

as the instructors. No other method was used in selection of the teachers for the study. Randomization of subjects and treatments was accomplished through use of random number tables for each of the schools participating in the study.

Teacher Training

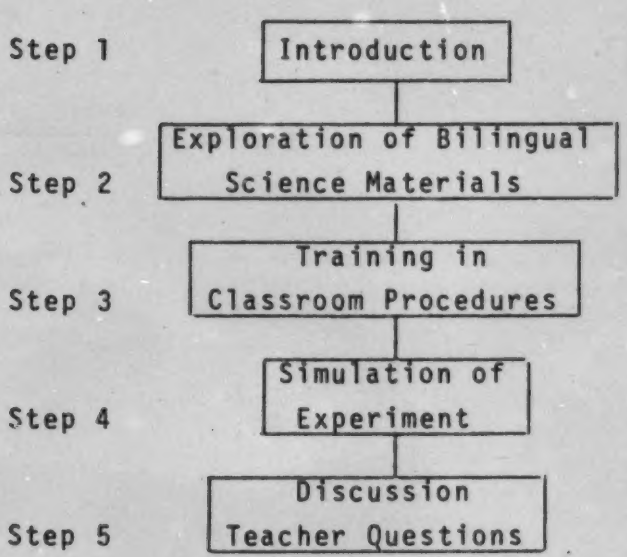
A teacher training program was initiated to familiarize the instructors with the program and the intent of the study. In addition, teacher variability while not completely controlled was assumed reduced by the training sequences shown in Figure 2 and the assignment of each teacher to the instruction of the four treatment groups in their respective schools. The four teachers participating in the study were bilingual. All teachers had sufficient command of both the English and Spanish languages to teach both the introductory and final activities. The language proficiency of the teachers was established by the state certifying agency, the college from which the teacher graduated and the directors of the bilingual projects. The ability of the teachers to demonstrate competence in the science activities was determined by the investigator in individual sessions with the teachers. No dependent measure was taken of the teacher competency in science other than having them demonstrate proficiency in the underlying concepts and the individual competency measures.

Research on Science--A Process Approach (AAAS, 1968) gave evidence that the amount of science a teacher had in college had little or no effect on the performance with Science--A Process Approach materials or techniques. The evidence was taken from the

many teacher training projects throughout the United States and pilot programs in various schools. The investigator assumed these findings valid for the purpose of the study. The teachers' ability to demonstrate the required competencies was verified through the training sequence described in Figure 2.

Figure 2

Teacher Training Sequence



Training Sequence

The study utilized a five step procedure in the training of bilingual teachers.

Introduction. In step 1 the teachers were introduced to Science--A Process Approach materials in general, in addition to those appropriate to the fifth grade level. A minimum of one hour was spent with the teacher in this endeavor and then the teacher was allowed to explore the materials.

Exploration of bilingual science materials. In step 2 the teacher was allowed to explore the materials to be used in both languages. The teachers were asked to take them home and go over them thoroughly.

Training in classroom procedures. Step 3 was devoted to discussing the specific processes, objective and sequencing of the activities for the classroom.

Simulation of experiment. In step 4 the teachers demonstrated to the investigator the ability to conduct the science exercises. The teachers utilized the materials and protocol called for in the science activities. These demonstrations were conducted in the absence of students.

Discussion of teacher questions. After the activities were completed, the investigator and teacher discussed any problems, real and anticipated. Questions were clarified on the data collection and the procedure of the experiment.

Training Activity

A minimum of twelve hours with each teacher was spent in training. This training was conducted during the teacher's preparation period and after school. During the actual implementation of the science activities, the investigator visited with teachers and observed classroom activities. All the training activities were carried out with individual teachers and not in group situations. During each week over a five week period, the

investigator would spend the first two days of the week with the northern schools, the third and fourth days with the southern schools and the fifth day in analysis of the work in progress and/or in preparation for the next week. Often, time on the fifth day was spent with teachers, program directors and university personnel involved in evaluation of the bilingual programs of investigative interest.

Materials

The supplies and additional literature for the instructors, including the required Spanish translation, were prepared by the investigator. To aid the instructor in introducing the first lesson, supplemental materials to distinguish between observation and inferences were provided by the investigator. Supplemental literature was also provided by the investigator for teacher use only. These materials and literature were not used in classroom situations but used only by the teacher during training (see Appendices A and B). The translation of English to vernacular Spanish of instructional materials was verified by practitioners in bilingual education (instructors at the university level, teachers and project personnel) and language specialists (Spanish language instructors and curriculum specialists).

EXPERIMENTAL TREATMENTS

The experimental scheme is shown in Figure 3. The competency measures relate to necessary prerequisite learning of

Figure 3

Experiment Sequence

For Treatment Groups

	Treatment	Instruction	Competency Measure 80%	Instruction	Competency Measure	Language Preference and Attitude Inventory
(1)	English-English	Sci * A/EL	measure	Sci B/EL	measure	Inventory
(2)	English-Spanish	Sci A/EL	measure	Sci B/SL	measure	Inventory
(3)	Spanish-English	Sci A/SL	measure	Sci B/EL	measure	Inventory
(4)	Spanish-Spanish	Sci A/SL	measure	Sci B/SL	measure	Inventory

* A = Content

B = New content for which A is a necessary condition

C = Context which is language

S = Spanish

E = English

subordinate-superordinate content and processes as well as facility with both English and Spanish. Each subject that was included in the study must have successfully completed the first competency measure and demonstrated 80 percent acquisition of observable behavioral skills as suggested by Science--A Process Approach (AAAS, 1968).

Science Content for Treatment Groups

All the treatment groups were instructed in two levels of science: one from Part D and one from Part E from Science--A Process Approach. As can be seen in Appendix C, the investigator made minor modifications in the materials. These materials were judged appropriate by the developers of Science--A Process Approach for the proposed age and grade level. Process skills from Science--A Process Approach, including Part D and Part E, are arranged in a hierarchial order and the levels presented to the subjects reflected that hierarchy.

The sequence chosen for investigation was Inferring from Science--A Process Approach (see Appendix D). This particular sequence occurs through several "Parts" which are units than can approximate grade levels. Parts D and E were used in the study because of their appropriateness for students in the fifth grade who had not earlier participated in the activities in Science--A Process Approach. In addition, Science--A Process Approach makes a clear distinction between the competencies required in Part D and Part E.

> Exercises in all eight of the basic processes are included in Part D. Observing 18 is the final exercise in the Observing process sequence, and only one or two exercises in the other basic processes will appear in later parts. Thus, when the children have completed Part D, their competence in all of the basic processes should be at a high level (AAAS, 1968).

Part E requires an integration of earlier skills and greater sophistication by the student.

> Exercises in seven of the basic processes and four of the integrated processes are included in Part E. The four integrated processes--Controlling Variables, Interpreting Data, Formulating Hypotheses, Defining Operationally--are introduced in this Part. Approximately 60 percent of the teaching time is devoted to the integrated processes. There are two exercises each on Formulating Hypotheses and Defining Operationally, and four exercises each on the other two integrated processes. (AAAS, 1968)

Subordinate and Superordinate Units

The subordinate science content was based on a set of activities from THE DISPLACEMENT OF WATER BY AIR (SAPA, Part D-Inferring 5, Section E) and required the students to construct inferences from observations and to test those inferences. The superordinate science content was based on INFERRING CONNECTION BATTERIES IN ELECTRIC CIRCUITS (SAPA, Part E, Inferring 7, Section A). Inferring 6 was not included as it was horizontal to Inferring 5 on the hierarchial chart (see Appendix D). The new set of activities in Part E provided a new situation for the student to demonstrate the transfer and elaboration of learning from one context to another and modifying and generalizing prior learning experience to a more sophisticated level. The new experience with inference required testing inferences and predicting future outcomes.

Sequence

As can be seen in Figure 3, after the initial treatment (subordinate science), the students were administered an individual competency measure (see Appendix E). The 94 of 104 students who successfully completed the first competency measure continued to the second treatment. The students who did not meet criteria were allowed to participate in the activities, but were not included in the final analysis. Success was defined as attainment of at least 80 percent of the specific task in the competency measure as specified by Science--A Process Approach. The score on the first dependent measure not only determined whether or not the individual would be a part of the final analysis, but after the administration of the first competency measure (dependent measure) the factorial design required a one way analysis of variance. The second individual competency measure (see Appendix F) provided the necessary data for the one way analysis of variance. In earlier studies, Walbesser and Carter (1968) discussed the validity of the competency measures as instruments for determining success in Science--A Process Approach.

All four treatment groups received 45 minutes of instruction on the same day. Instruction days between schools differed slightly due to the number of students in each of the schools. The instructional period covered a minimum of 20 days, and the number of activities covered was consistent from school to school. As can be seen in Figure 4, when a particular activity was being presented, each treatment group at each school received the same

Figure 4

The Pooling of Treatment Groups

for Purposes of Instruction

Subordinate Science Instruction			
Same Day	Science Activities		
1st Hour	Treatment Group I (English)	AND	Treatment Group II (English)
2nd Hour	Treatment Group III (Spanish)	AND	Treatment Group IV (Spanish)
Superordinate Science Instruction			
Same Day	Science Activities		
1st Hour	Treatment Group I (English)	AND	Treatment Group III (English)
2nd Hour	Treatment Group II (Spanish)	AND	Treatment Group IV (Spanish)

set of activities. Additionally, in order not to differentiate in terms of time and quality between treatment groups in the same language groups, those that were to receive their instruction in English were pooled and those who were to receive their instruction in Spanish were pooled. The teacher, therefore, had to teach the lesson twice (Spanish and English) instead of four times. The result was that the different treatment groups received the same procedure within their assigned language set.

DEPENDENT MEASURES

Competency Measures

Evaluation instruments were designed by the authors of Science--A Process Approach to measure performance by students on the specific parts of the program. These measures were called competency measures, and were prepared in the form of separate tests, each to be administered after completion of a relevant section of instruction. For this study, the researcher chose two of these measures, each corresponding, as specified by Science--A Process Approach, to the selection of content used in the investigation. For example, in this study the two competency measures were administered to students who participated in the science activities related to Inferring 5 (e) from Part D and Inferring 7 (a) from Part E of Science--A Process Approach (see Appendix C for a description of these sections). The children were allowed to answer questions on the competency measure in the language of their choice. The scoring on the competency measures was done by using a binomial

scale: the performance of behavior is either acceptable or not acceptable. The teacher scored the first competency measure and the investigator scored the second competency measure.

The competency measures are designed to sample the attainment of the objectives stated at the beginning of the exercises. While the tasks on the competency measures are not duplicates of the tasks in the activities, they are similar enough so that the student can apply and generalize what he has learned in the activities leading up to the tasks on the competency measures. The strategy is to get the student to apply what he has learned in the science activities to new situations rather than using straight recall or rote memorization.

Validity. The validity of the instruments or competency measures was assumed because Science--A Process Approach stated that the publishers had carefully tested the competency measures in their tryout groups over a three year period. It was also this researcher's opinion that the competency measures used were relevant to the instruction under investigation, and therefore had sufficient content validity to be appropriate measures.

Reliability. The investigator used the Kuder-Richardson Coefficient Formula 21 (Ferguson, 1971) for determining the internal consistency of the competency measures.

As can be seen in Table 2, the first competency measure had a reliability coefficient of .12 and the second competency measure had a reliability coefficient of .63. These results were lower

bound approximations based on the overall group means and variances. The low reliability coefficient for the first competency measure was due to the generally low total variance in the groups and the number of items on the first competency measure. It should also be recognized that a more discriminating test is needed, but the nature of the individual administration of the competency measure precludes the addition of sufficient items to increase the reliability. The students performed well, as Science--A Process Approach expects them to; but it must also be recognized that the children performed equally well in Spanish and in English.

The reliability coefficient for the second competency measure indicated that the measure as a whole tended to discriminate among subjects. This tends to support the selection of the exercises from Science--A Process Approach as being in sequential order because there is a considerable difference in the coefficients of the first and second dependent measures.

Table 2

Kuder-Richardson Coefficient Formula 21
for Each Administration of Each Competency Measure

	N	Number of Items	r
First Competency Measure	104	5	.12
Second Competency Measure	94	13	.63

Language Preference and Attitude Inventory

At the end of the final instructional sequence a limited

response inventory was administered to the students. The language preference and attitude inventory consisted of fifteen questions and was directly related to the science activities and classroom environment in general. Content validity was assumed by the investigator based on question types utilized in other attitude and language preference inventories except that the inventory was bilingual in nature. Fourteen of the questions were of the limited response type; i.e., A or B or C, and the fifteenth was an open-ended question for the students to fill in. The inventory was administered in English and Spanish (see Appendix G). The group that had final instruction in English received the English version of the inventory and the subjects that received final instruction in Spanish received the inventory in Spanish. The rationale for the Spanish and English inventory was to detect if bilingual education and the science activities had any relation to the students' answers.

RELATIONSHIP OF DESIGN TO HYPOTHESES

The design set up an experiment that would enable the investigator to test the stated hypothesis of transfer of learning science content in language complexes and language dominance in learning. The experiment had built-in controls relative to Treatment Group Two (English-Spanish) and Treatment Group Three (Spanish-English); Treatment Group One (English-English) and Treatment Group Four (Spanish-Spanish) act as controls in this respect.

Treatment Group One

Treatment Group One, in the design, received total instruction in English. This group's performance when compared with the other three groups should indicate whether or not subjects instructed in English performed significantly better on science content and process skills. All groups were minimally bilingual as determined by the teacher and had participated in bilingual education for at least four years prior to the study. Because the population selected for study was heterogeneous when language and academic skills were examined, there was equal chance to demonstrate that the English instruction is superior to other types of instruction within the parameters of the study. A significant difference in favor of the English-English treatment as opposed to English-Spanish, Spanish-English, and Spanish-Spanish would indicate that, at this particular grade level, within the limitations of the study and design, English might be the preferred method of instruction for unicultural science content.

Treatment Group Two

Treatment Group Two had English instruction first and Spanish second. This enabled an examination of subordinate-superordinate learning when first instruction is in English and second in Spanish. While this would be the case for other treatment groups, it became more critical when the language of instruction as well as the science context is changed. Assuming that the instructors were competent following training, success on

both the first and second competency measures would indicate that the transfer effect hypothesized is correct because the first and second competency measures are the dependent measures for the analysis. The degree of success of Treatment Group Two on the second competency measure allowed a comparison to be made with the other treatment groups. A significant difference in performance by Treatment Group Two would suggest that this is the most appropriate instructional sequence of the groups. Failure to succeed or a poor performance, in terms of degrees of success, would lead to the conclusion that this mode of instruction is not as desirable as that in those treatment groups showing superior performance. Because this particular treatment group had the language of instruction changed (English to Spanish) from subordinate to superordinate levels and because the treatment is language dependent, the results would also lead the investigator to conclude that the transfer effect is only minimally successful and other contingencies must be taken into account. It might be that repetition of instruction in both languages or in one language is necessary and that the subjects are expressing a language preference.

Treatment Group Three

Treatment Group Three, Spanish-English, was the inverse of Treatment Group Two in the sequence of language. Treatment Group Three had Spanish instruction first and English instruction second. Superior performance by Treatment Group Three would indicate that the transfer of learning science processes and

content has occurred in relation to the Spanish-English sequence. The degree of success on the second dependent measure would allow the investigator to state that this is the preferred method of instruction. Failure to achieve success would result in the same conclusions as Treatment Group Two.

Treatment Group Four

Treatment Group Four, like Treatment Group One, was instructed in only one language. Treatment Group Four was instructed in Spanish which would enable the group to demonstrate a preference for or difficulty in this type of instruction when compared with the other three groups. A significant difference in favor of the Spanish-Spanish treatment as opposed to English-Spanish, Spanish-English, English-English would indicate that at this particular grade level, within the limitations of the study and design, Spanish might be the preferred method of instruction for unicultural science content.

LIMITATIONS

Most researchers that initiate a study in bilingual education find themselves in the uncomfortable position of crossing many disciplines. This becomes of increasing concern when the researcher is interested in a particular discipline, as was the case with this study. This researcher's interest lies in bilingual science education. The investigative problems immediately surfaced: Would the linguistic aspects be adequately dealt with? Would there be a clear line of demarcation between

science education and linguistic concerns? Would there be an adequate treatment of language and cognition? Certainly there were other questions that could be asked of a study of this nature, but a caveat must be interjected at this point. This study did not attempt to exhaust the study of bilingualism and the learning of science.

This study was an attempt to add a small but significant bit of information to an area that is much like a sleeping giant. Sometimes it is better to get an accurate profile of the dimensions of a field of study in order to place an idea into proper perspective, and sometimes we can learn a lot by taking a small core sample.

Lack of control of factors that vary systematically with the experimental treatments provide a threat to the validity of the study. Limitations included:

1. Geographic location of schools. As noted earlier, not only were there 400 miles of separation between the northern and southern schools, but differences in the location of the schools within the towns themselves. Additionally, the southern schools were closer to Mexico (45 miles) while the northern schools were located in areas that had had permanent residents for several generations.

2. School environments. The school buildings and personnel were quite different. For example, some schools had Anglo principals and some had Chicano principals. The classrooms varied from school to school. Some classrooms were self-contained

with running water while others had no running water or were not self-contained. Some of the classrooms were permanent parts of the school building and others were temporary units.

3. Teacher differences. Teachers differed in age and tenure. Their teaching experience ranged from one year to beyond seven years. Teaching experience with bilingual education followed much the same pattern. Preparation ranged from Bachelors to Masters degrees. There were three female and one male teacher.

4. Homogeneity of subjects. Students differed in home environments. Some students came from rural farms and were bussed to school and others lived in town within walking distance of the school. Some students had more exposure to media (radio, television, newspapers, movies) than other students. The language of the home varied from those that had total communication in Spanish to those that used considerable English.

The list of limitations mentioned is not exhaustive but is included to indicate that the investigator was keenly aware of existing circumstances.

Chapter 4

ANALYSIS OF DATA

In this chapter the analysis of data and statement of findings are grouped according to statistical hypothesis. Three of the null hypotheses were tested by the analysis of variance (Edwards, 1968) and one by use of Fattu's Nomograph (1939). In all tests Alpha was set at 0.05.

INSTRUCTION IN SUBORDINATE SCIENCE ACTIVITIES

There were 104 subjects in the study, as can be seen in Table 3, divided approximately equally into four treatment groups. Table 3 also shows the number of subjects per treatment per school and indicates that there were nine subjects which did not meet the 80 percent criterion level established and were eliminated from the study. There was no trend nor significant difference established concerning which language treatment had the greatest attrition (see Appendix H for raw scores). The English-English treatment had the same mean attrition as did the Spanish-Spanish treatment. One successful subject from School B dropped from the study. This reduced the N of 95 to 94 students who successfully met the competencies required by the science activities related to "Inferring 5" from Part D of Science--A Process Approach and who participated.

Table 3

Number of Subjects Per Treatment Group by School

School	Number Taking Competency Measure	Treatment I (Eng-Eng)	Treatment II (Eng-Span)	Treatment III (Span-Eng)	Treatment IV (Span-Span)	Number Who Met Selection Criteria
A	23	6	4	4	5	19
B	26	6	6	5	7	23
C	24	6	5	6	6	23
D	31	6	8	8	7	29
Total	104	24	23	23	25	94

The analysis indicated that the majority of students had acquired and demonstrated the competencies required by the dependent measure for the subordinate science activities and were ready for the second set of science activities at the superordinate level.

INSTRUCTION IN SUPERORDINATE SCIENCE ACTIVITIES

Table 4 presents means and standard deviations for each of the four treatments grouped according to school. The data indicates that there was little variation among or within schools and the standard error indicates that the means were accurate estimates of the parameters. The deviations about the mean were also close among groups.

STATISTICAL ANALYSIS

Table 5 shows the sums of the means of treatment groups and the sums of the means of schools. Presenting the means as single observations as depicted in Table 5 allows the investigator to conduct the analysis when there were unequal N's (Edwards, 1968). The analysis of variance using means as single observations is shown in Table 6.

Table 4

Means and Standard Deviations on Second Competency Measure by Schools

School A	Dependent Variable	N	Mean	Standard Deviation	Standard Error
Group I	1	6	10.167	1.169	.477
Group II	1	4	9.500	2.082	1.040
Group III	1	4	9.750	1.708	.854
Group IV	1	5	8.800	1.789	.800
School B					
Group I	1	6	13.000	.000	.000
Group II	1	6	12.833	.408	.167
Group III	1	5	12.800	.447	.200
Group IV	1	6	13.000	.000	.000
School C					
Group I	1	6	12.333	.817	.333
Group II	1	5	12.200	.447	.200
Group III	1	6	11.000	2.608	1.065
Group IV	1	6	12.167	.408	.167
School D					
Group I	1	6	12.167	.753	.307
Group II	1	8	12.500	.535	.189
Group III	1	8	12.375	.518	.183
Group IV	1	7	12.429	.535	.202

Table 5

Summary of Treatment Group Means by School

	Group 1	Group 2	Group 3	Group 4	Sum of Means
School A	10.167	9.500	9.750	8.800	38.217
School B	13.000	12.833	12.800	13.000	51.633
School C	12.333	12.200	11.000	12.167	47.700
School D	12.167	12.500	12.375	12.429	49.471
	47.667	47.033	45.925	46.396	186.021

In the estimation of variance and experimental error a correction factor is attached to the within treatment mean square, MS_w:

$$SS_w = \sum_1^{n_1} x + \sum_2^{n_2} x + \sum_3^{n_3} x + \ldots + \sum_{16}^{n_{16}} x = 90.370$$

$$df = \sum (n-1) = 78$$

$$MS_w = 1.159$$

The correction is

$$c = 1/k \sum_1^k 1/n_k = 1/16(1/6 + 1/4 + 1/4 + \ldots + 1/7) = 0.177$$

and the estimation of the variance becomes

$$cMS_w = 1/k \sum_1^k 1/n_k \; MS_w = (1.159)\ (0.177) = 0.205$$

Continuing with the sum of squares based on the data contained in Table 5.

$$\text{Cell} = (10.170)^2 + (9.500)^2 + (9.750)^2 + \ldots + (12.429)^2 - \frac{(187)^2}{16} = 29.417$$

$$\text{Schools} = \frac{(38.217)^2}{4} + \frac{(51.633)^2}{4} + \frac{(47.700)^2}{4} + \frac{(49.470)^2}{4} - \frac{(187)^2}{16} = 26.629$$

$$\text{Treatments} = \frac{(47.670)^2}{4} + \frac{(47.030)^2}{4} + \frac{(45.930)^2}{4} + \frac{(46.400)^2}{4} - \frac{(187)^2}{16} = 1.130$$

School X Treatments = Cells - Schools - Treatments

= 29.417 - 26.629 - 1.130 = 1.658

Schools

In reference to Table 6, the analysis of variance shows that there is a significant F for schools.

Table 6

Analysis of Variance for All Treatment Groups on the Second Competency Measure

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Schools	26.629	3	8.876	43.384*
Treatment Groups	1.130	3	0.377	1.841
School X Treatment	1.658	9	0.184	0.901
Residual (error)	90.370	78	0.205	

*Significant at 0.05

To be significant, F (.05) had to be greater than 2.720. The value of F was calculated to be 43.384 which is highly significant influenced primarily by School A. Other socio-demographic variables as noted in limitations may have influenced the significant F, but these variables were not statistically investigated. The significant F was expected since the 2 x 2 factorial design called for complete replications in four different schools. The statistic indicates that the schools differ in overall level of performance.

Treatment Groups

The calculated value for F showed there was no significant difference between treatment groups in the four schools. To be significant F (.05) had to be greater than 2.720. The calculated value of F was 1.841 which did not approach significance.

Interactions

The calculated value for F showed there was no significant interaction when schools were crossed with treatments. To be significant, F (.05) had to be greater than 1.990. The value of F was calculated to be 0.901 which did not approach significance.

STATISTICAL HYPOTHESES

Hypothesis One

Subjects experiencing instruction in Spanish will not perform significantly better on science competency measures than those subjects exposed to English instruction when the scientific content is unicultural in nature.

This hypothesis as stated in the null form was accepted as there was no significant difference between any of the treatment groups (see Table 6). It was concluded that bilingual subjects having total instruction in Spanish performed no better on the science competency measures than those bilingual subjects instructed bilingually in Spanish and English. They also performed no better than bilingual subjects who received their total instruction in English.

Hypothesis Two

> Subjects experiencing instruction in English will not perform significantly better on science competency measures than those subjects exposed to bilingual (Spanish and English) instruction when the scientific content is unicultural in nature.

This hypothesis as stated in the null form was accepted as there was no significant difference between any of the treatment groups (see Table 6). It was concluded that bilingual subjects having total instruction in English performed no better on the science competency measures than those bilingual subjects instructed bilingually in Spanish and English. They also performed no better than bilingual subjects who received their total instruction in Spanish.

Hypothesis Three

> Subjects experiencing instruction in Spanish will not perform significantly better on science competency measures than those subjects exposed to bilingual (Spanish and English) instruction when the scientific content is unicultural in nature.

This hypothesis as stated in the null form was accepted as there was no significant difference between any of the treatment groups (see Table 6). It was concluded that bilingual subjects having total instruction in Spanish performed no better on the science competency measures than those bilingual subjects instructed bilingually in Spanish and English. They also performed no better than bilingual subjects who received their total instruction in English.

Hypothesis Four

> Considering all the subjects within the study without regard to treatment groups there will be no significant difference between the proportion of bilingual children preferring a bilingual approach to science instruction when compared with the proportion of bilingual children preferring monolingual science instruction.

The null hypothesis associated with statistical Hypothesis Four was rejected. This was accomplished by using two statistical methods: Fattu's Nomograph (1939) and the binomial distribution. As a result of these two statistical procedures, it was found that there was a significant difference, at the .05 level, in favor of the bilingual environment.

There were fourteen items analyzed on the Language Preference and Attitude Inventory; three items (1, 3, 8) related to the value and difficulty of the science activities, and eleven items (2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14) pertained directly to a language environment. The students chose a bilingual environment on ten of the eleven items, rendering this statistically significant. See Appendix I for an analysis by item. The statistical significance

was accomplished by summing percentages of A and B against C using Fattu's Nomograph (1939) and then testing the hypothesis by the binomial distribution. Except for those students absent, all students, including those unsuccessful on the first competency measure, were administered the Inventory.

The analysis of each of the items on the Language Preference and Attitude Inventory was accomplished by computing absolute and relative frequencies on each item on the Inventory. Each frequency was then analyzed by using Fattu's Nomograph (1939) for testing the significance of the difference between percentages. Table 7 presents this distribution and analysis.

The questions on the Inventory are interrelated and are directed toward the experience that the children had with the science exercises. The questions also relate on a more general basis to the children's overall reaction to bilingual education. To simplify the interpretation of the Inventory, the questions are classified into three categories as follows:

Attitude toward science instruction. Included in this category were five questions dealing with science instruction and students' attitude toward that instruction.

1. I feel the science activities we did in class the last two weeks were:
   A. Very difficult for me to understand
   B. Sometimes easy for me to understand and sometimes not easy to understand
   C. Clear and easy for me to understand
2. I think that I can learn science better when it is taught in:
   A. Spanish
   B. English
   C. both Spanish and English

Table 7

Frequencies and Percentages

for the Language Preference

and Attitude Inventory

Question	N*	Percentage of N answering			Significance			
		Choice A	Choice B	Choice C	AvB	AvC	BvC	A+BvC**
1	101	7	57	36	.01	.01	.05	
2	101	7	31	62	.01	.01	.01	.05
3	101	3	20	77	.01	.01	.01	
4	101	7	24	69	.01	.01	.01	.05
5	101	7	30	63	.01	.01	.01	.05
6	101	8	14	78	NS	.01	.01	.05
7	101	11	18	71	NS	.01	.01	.05
8	101	5	33	62	.01	.01	.01	
9	101	12	8	80	NS	.01	.01	.05
10	101	18	44	39	.05	.01	.01	
11	101	14	26	60	.01	.01	.01	.05
12	101	11	31	58	.01	.01	.01	.05
13	101	5	12	83	NS	.01	.01	.05
14	101	10	31	59	.01	.01	.01	.05

*The N reflects the total number of students available when the Inventory was administered.

**In the bilingual category Choice C was selected in ten out of eleven possible items.

3. The way science activites were presented in our class the last two weeks was:

   A. of little or no value to me
   B. of some value to me
   C. of great value to me

8. The language that the teacher used in explaining our science activities was:

   A. not very understandable
   B. sometimes understandable
   C. almost always clear and understandable

11. I think the science activities were more interesting when the students talked in:

   A. Spanish
   B. English
   C. both Spanish and English

In summary, the students' overall reaction was that the science activities were challenging but were neither too easy nor too difficult. The pupils also indicated that they preferred bilingual instruction and felt that the knowledge gained was of great value. The students thought that the teacher's explanations and instructions were clear and felt that the activities were more interesting when the students conversed in both English and Spanish.

Preference and attitude regarding the instructional environment. This category conveys the students' expressed preference and attitude regarding the instruction environment.

4. I feel better when the teacher talks in:

   A. Spanish
   B. English
   C. both Spanish and English

6. I think we should use more:

   A. Spanish materials in class
   B. English materials in class
   C. materials using both the English and Spanish language

7. I think the school should offer more subjects in:

   A. Spanish
   B. English
   C. both Spanish and English

12. I feel better when our lessons are in:

   A. Spanish
   B. English
   C. both Spanish and English

14. I am able to pay attention better to the class work when the instruction is in:

   A. Spanish
   B. English
   C. both Spanish and English

The students expressed the opinion that they preferred the teacher to speak bilingually and the need for more bilingual materials. The students also expressed a desire to have more subjects or disciplines taught bilingually. The students felt better when the instruction was bilingual and felt that they attended more to lessons when they were conducted bilingually.

Attitude about bilingual education in general. This category indicated the students' expressed opinica about bilingual education in general.

5. I like to speak:

   A. Spanish in class
   B. English in class
   C. both Spanish and English in class

9. I believe school is more interesting when:

   A. the teacher teaches in Spanish
   B. the teacher teaches in English
   C. the teacher teaches in English and Spanish

10. When I explain something I can do it better using:

   A. Spanish
   B. English
   C. Spanish sometimes and English sometimes

13. If I had my choice I would go to a school where:
    A. only Spanish is used in the classroom
    B. only English is used in the classroom
    C. both English and Spanish are used in the classroom

The students indicated that they preferred to speak both English and Spanish in class, but felt that they could express themselves better in English. A possible explanation is that the dominant language outside the home is English which is reflected in the media. They believed that school was more interesting when teachers were bilingual and preferred to go to a bilingual school.

Explication of the Inventory. Table 7 presents the frequencies and percentages for responses to each of the questions and the level of significance attached to each question. Appendix G presents the questions in the order in which they appear in the Inventory. The questions are shown in both English and Spanish, although as can be seen in Appendix G the English and Spanish Inventories are separate. Appendix I presents the analysis of the questions allowing a comparison to be made between each question and the significance attached to it.

SUMMARY

The analysis of data indicates that there was no significant difference between treatment groups. There was a between school difference but this difference is normally expected when using several schools in a study such as this. The students did indicate a preference for bilingual instruction and for an environment that reflected both the Spanish and English languages.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to determine if single language instruction was any more efficacious than bilingual instruction in a science context. A main concern of the study was to investigate the transfer of learning science content and process skills from one language to another. Additionally, information was sought on the students' reaction to bilingual science instruction.

The study involved 104 fifth grade children from four different schools in New Mexico that had had bilingual education for at least four years prior to the study. The students were randomly assigned to one of four treatment groups at each of the four schools. The four treatment groups were instructed in subordinate and superordinate units of science.

Treatment I (English-English): This group was instructed in English only on both the initial and final units of science instruction.

Treatment II (English-Spanish): This group received initial instruction in English and final instruction in Spanish.

Treatment III (Spanish-English): This group received initial instruction in Spanish and final instruction in English.

Treatment IV (Spanish-Spanish): This group received instruction in Spanish only on both the subordinate and superordinate units of science instruction.

When the classrooms were selected, the teachers in each of the four schools were naturally selected as the instructors for the study. Thus, each bilingual teacher was responsible for four treatment groups within his/her school with equal replications in each school.

Prior to instruction all teachers were trained in the use and presentation of the selected science units. This training program was initiated to familiarize the instructors with the program and the intent of the study. In addition, teacher variability while not completely controlled was assumed reduced by the training program.

Three dependent measures were administered to the students. The first dependent measure sampled the student performance in initial science instruction. This measure was administered immediately after instruction in the subordinate science activities, and each child took the individual competency measure. The student was required to score correctly on at least 80 percent of the measure to meet criterion. The second dependent measure sampled the student performance on the final set of science activities. This measure was also administered individually and immediately upon completion of all activities in the unit.

Both the initial and final activities in science were taken from a set of exercises from Science--A Process Approach.

The third dependent measure was administered to all students to measure student language preference and attitude toward science instruction. This measure was administered after completion of both science activities and was administered in both English and Spanish.

Findings

The analysis of data and statement of findings are grouped according to statistical hypotheses. Three of the null hypotheses were tested by the analysis of variance and one by use of Fattu's Nomograph. In all tests, Alpha was set at .05.

1. There were no significant differences among treatment groups and it was concluded that subjects experiencing instruction in Spanish did not perform significantly better than other treatment groups. Thus, the null hypothesis was accepted.
2. Subjects experiencing instruction in English did not perform significantly better than other treatment groups.
3. Students instructed in Spanish performed no better on dependent measures than those instructed bilingually.
4. The students showed a statistical preference for a bilingual environment as opposed to a monolingual environment. This was significant at the .05 level.

Conclusions

The major finding of the study was that there was no significant difference between treatment groups receiving instruction bilingually or having instruction in a single language. The students receiving total instruction in English did no better on the dependent measures than those students receiving total instruction in Spanish, and students receiving instruction in both Spanish and English performed just as well as those instructed in a single language.

The data in this experiment indicate that the students have reached a level of language fluency and competency which allows science instruction in either Spanish or English and can be expected to demonstrate learning abilities equally well in both languages. Thus, bilingual children in this study in the fifth grade, after having been instructed bilingually for four years prior to the study, can perform on specific learning tasks as well in Spanish as in English. This finding tends to support one of the underlying assumptions of bilingual education: that is, by using the language that the child is more familiar with will facilitate his cognitive/academic development and by incrementing instruction in the weaker language it is expected that, after a period of time, there will be equal facility in learning through the use of both languages regardless of subject matter or content.

There are other possibile pertinent interpretations that might be drawn from these findings. For example, it might be concluded that these results stemmed from the teachers teaching

for the test. This investigator judges that this interpretation is not likely, based on the training procedures employed, his careful monitoring of both the teaching and testing conditions, and his judgment of the teachers' own professional conduct.

Further, this interpretation could be tested only by employing either a different curriculum not so structured, or by using criterion measures completely independent of the curriculum.

Because Science--A Process Approach is designed to foster success, this could account for the relative lack of difference in the performance of the children. However, this conclusion was not statistically tested.

The students preferred a bilingual environment as opposed to a monolingual environment.

There were other outcomes of the study that are directly related to bilingual education. The first is support for the idea that the bilingual teacher does not have to repeat the lesson verbatim in both languages for students and the second is that the experimental design does provide a measure for the classroom teacher to investigate language dominance in bilingual children. The teacher should be able to judge the extent that children have moved toward the postulated equal facility in learning regardless of language of instruction.

RECOMMENDATIONS

Recommendations for Further Research

This study on bilingual science education does carry with

it implications for further refinement and research. Some of the recommendations may help in the development of such a research endeavor.

Extension of the study. In investigating and evaluating bilingual programs, a continuous effort to seek those schools that reflect rural and metropolitan areas separately should be made. Studies that are conducted in large metropolitan areas are seldom valid in rural situations, notwithstanding the geographic areas. Nonetheless, much information generated from studies in metropolitan areas have been extrapolated to the rural classroom. Information needs to be generated in as many bilingual school environments as possible.

Additional process skills. Science exercises in this study were taken from Part D and Part E from Science--A Process Approach. The set of exercises centered around the basic science process skills of observing, inferring, and predicting. These activities are listed as part of the basic process skills. The experiment could be carried out over a period of a year utilizing some of the integrated process skills from Science--A Process Approach which requires a greater sophistication on the part of the student. One indication from the study was that the students performed rather equally across groups; the integrated process skills might serve to statistically distinguish between treatment groups.

Bilingual programs in schools develop horizontally, vertically, or a combination of these two methods. Horizontally,

they start bilingual instruction in a particular grade in a school and expand it to other schools. Vertically, the bilingual programs continually add a grade level each year; for example, if they start with the first grade in a school, the next year the program would include the second grade. A combination of these approaches is found in bilingual programs. As a recommendation for further research a greater number of classrooms might be included and a vertical arrangement of the selected classrooms ranging in exercises from the basic process skills through the integrated skills.

Additional dependent measures. The dependent measures were administered immediately upon completion of the several activities in a particular exercise. Although the testing of individuals might take several days the results gave indications of the immediate retention effects. Perhaps a measure should be made a week or two or longer after instruction. This situation would allow for a delayed measure of learning in addition to the immediate retention effects.

Language preference and attitude. The Language Preference and Attitude Inventory should include a larger number of items in categories of attitude toward science instruction, preference and attitude regarding the instructional environment, and attitude about bilingual education in general. Those areas of the Inventory in which there was no significant difference between items merits further scrutiny.

Modification of testing technique. As a recommendation for further study, the competencies of individuals should be assumed to be randomly distributed among the treatment groups so that only a random sample of those pupils included in the study would validate the experiment. The administration of the individual competency measures or the manner in which the individual testing is conducted is too time consuming for the instructor to administer to an entire class in an experiment of this nature. The aforementioned suggestion would also allow for a larger number of items to be included on the dependent measures to make the individual examinations more discriminating.

Recommendations for Existing or Proposed Bilingual Programs

The following recommendations are not drawn from the empirical findings in this study, but are inferred from experiences and observations in the field. These recommendations are directed to existing or proposed bilingual programs. While in most cases the recommendations are directed to specific areas of bilingual education; e.g., science, social studies, etc., they are general enough to be applicable in most bilingual program situations.

Cultural influence in science education. The need for constructing a bilingual science curriculum is highly desirable for bilingual programs. However, as is recognized in most national curricular projects, especially the science oriented ones, the cost is quite high. The cost factors do seem prohibitive and concomitantly there is a dearth of resource people with expertise in bilingual

science education which might be involved in the program preparation. Nonetheless, bilingual science curricular materials are in high demand by individual bilingual projects and indications are that they will continue to be in high demand.

Perhaps the best method for a short range solution is to take techniques and materials developed for use in the United States and adapt or modify the materials to a bilingual situation. Certainly this idea is not unique as many materials developed in the United States are in use, in a Spanish translation in Spanish speaking countries. Thus, by using materials and curricula developed for use in the United States and modified and translated for Spanish speaking countries, it is quite possible to again modify the Spanish translation of these materials for use in a bilingual situation. As a short range plan, for immediate utilization by projects, this idea might be feasible, though not the most desirable if a national bilingual science program is needed.

Many projects are currently developing science units that are historically or culturally suited to a particular region or geographical area. This idea could serve until sufficient projects have utilized science curricular units that are project specific. Time would then allow for national scrutiny of these local projects and the development of general trends to guide a national bilingual project in science education.

It is quite evident from field observations that bilingual education needs a sequential program in bilingual science education. This is especially significant in that many of the

Spanish speaking bilingual programs are in their fifth year of continuation. Some programs have now expanded into the secondary schools and it is very important that a firm foundation in science be articulated from elementary through secondary schools. It is also clear that science education in bilingual schools can no longer be given low priority in contrast to other subjects that have dominated the concern of bilingual educators.

Implications for teacher training. Teacher training institutions should include in their science methods courses laboratory experience in science education with some aspects of a pluralistic society. Bilingual methods courses should aid and foster the use of science as viable an avenue to intellectual and academic growth as any other content area. Bilingual methods courses, along with elementary and secondary science methods courses are not mutually exclusive and every opportunity should be taken to exploit those areas of mutual concern. The training of teachers, both pre-service and in-service, in bilingual science education should no longer be ignored.

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APPENDIX A

SUPPLEMENTAL LITERATURE FOR TEACHER TRAINING
FROM GUIDE FOR INSERVICE INSTRUCTION
SCIENCE--A PROCESS APPROACH
(AAAS, 1967, p. 11)

OBSERVATIONS AND INFERENCES

In the exercises to follow the child should begin to distinguish between observations (what a person sees, smells, hears, touches, and tastes) and inferences (what a person thinks is responsible for what is observed, or how a person explains his observations). If the children do not know the distinction between observations and inferences, demonstrate to them that an observation is something that a person sees, touches, hears, smells, tastes---in other words, something that a person experiences with his senses. Explain that an inference is a person's idea about how his observations might be explained or accounted for.

It is important that children use the terms correctly in their science activities, and it is also important that they use them correctly in other activities.

Observations are basic to any scientific investigation. These observations in turn lead to the construction of inferences that can be tested by further observation. Therefore, observing provides both a basis for constructing inferences and for testing existing inferences.

Observations are statements of properties that can be perceived by use of the senses. A statement such as, "This cube is made of sugar", is not acceptable as an observation because "sugar" is not a property perceived by the senses. For example: I observe that an object is white; that it is a cube with edges;

that it tastes sweet*; that it is odorless; and that it disappears (dissolves) when placed in water. I infer, on the basis of these observations, that the object is sugar.

Conclusions or ideas are called inferences. An inference is a statement about a specific event or object that is based on observations but which itself is not an observation. It may be an explanation of the observation.

Learning to make careful and valid inferences in scientific work requires a critical attitude toward one's own inferences as well as those of others. From now on, you should try to develop this critical attitude by reinforcing the conscious distinction between an inference and an observation as the situations arise. Ask questions such as: Is that an observation? Did you actually see a dog run away with your ball? Or is that an inference? In other words, is that what you think may have happened?

VOCABULARY

Observation	Senses	Displacement
Inference	To infer	Displace

APPENDIX B

SUPPLEMENTARY LITERATURE FOR TEACHER TRAINING
FROM CONSULTOR-CIENCIAS NATURALES NIVEL 5
(SANTILLANA, 1971, pp. 5-27)

¿QUE ES OBSERVAR?

EL PROFESOR POLINOMIO ENSEÑA A LOS NIÑOS LO QUE ES OBSERVAR.
PARA OBSERVAR ALGO, TENEMOS QUE USAR LOS SENTIDOS Y SÓLO LOS SENTIDOS. UNA BUENA OBSERVACIÓN SERÁ LA QUE SE LIMITE EXCLUSIVAMENTE A LO QUE APRECIAMOS CON LOS SENTIDOS: VISTA, OÍDO, OLFATO, ETC.
¡ES UNA NARANJA!
ESO NO ES OBSERVAR: HAS UTILIZADO TUS CONOCIMIENTOS, ADEMÁS DE LOS SENTIDOS. PARA OBSERVAR HAY QUE USAR SOLAMENTE LOS SENTIDOS Y NO LOS CONOCIMIENTOS QUE YA TENEMOS.
¿ENTONCES NO ES UNA NARANJA?
¡CLARO QUE LO ES! PERO SI NOS LIMITAMOS A OBSERVAR, SÓLO PODREMOS DECIR LO QUE NUESTROS SENTIDOS PERCIBAN: EL COLOR, LA FORMA, EL SABOR, ETC.
LOS NIÑOS HACEN OBSERVACIONES DE LAS NARANJAS.
TIENE FORMA ESFÉRICA Y ES DE COLOR ANARANJADO.
POR DENTRO ESTÁ HÚMEDA Y TIENE SABOR DULCE.
PESA UNOS DOSCIENTOS GRAMOS.
AHORA YA SABEN OBSERVAR; VAMOS A HACER ALGUNAS PRÁCTICAS.
¡A LA MÁQUINA DEL TIEMPO!
¡ESO!
¡ESO...
LA MÁQUINA DEL TIEMPO LOS TRASLADA 300 AÑOS ATRÁS Y A UNA ISLA INEXPLORADA.
EN ESTA ÉPOCA, MUCHOS LUGARES DEL PLANETA ESTABAN SIN EXPLORAR. LOS BUENOS EXPLORADORES DEBÍAN SABER OBSERVAR... DE ELLO DEPENDÍAN MUCHAS VECES SUS VIDAS. ¡AVER QUÉ TAL LO HACEN!

ESO QUE DICES CREO QUE NO ES UNA OBSERVACIÓN...
¡MIREN, APENAS MOVEDIZAS! COMO EN LAS PELÍCULAS DE LA SELVA...
¡MUY BIEN, JAIME! LO QUE HA DICHO MONCHO ES UNA INTERPRETACIÓN.
¿INTERPRETACIÓN?
SÍ, MONCHO: CONFUNDES OBSERVAR CON INTERPRETAR. UNA INTERPRETACIÓN ES UTILIZAR LO QUE SABEMOS, ADEMÁS DE LO QUE NUESTROS SENTIDOS NOS INDICAN.
¡CLARO! IGUAL QUE HICE YO CON LA NARANJA.
¡BUENO, PUES AHORA SÍ QUE NO ME EQUIVOCO!: UNA EXTENSIÓN DE TERRENO DE COLOR MARRÓN; EL SUELO ES ALGO BLANDO, NO TIENE VEGETACIÓN....
¡...Y ME HUNDO EN EL CUANDO ME SITUO EN EL CENTRO!
¡¡¡SOCORROOO!!!
¡ESA SÍ QUE ES UNA BUENA OBSERVACIÓN!
CREO QUE YA VOY COMPRENDIENDO ESTO DE OBSERVAR
YO TAMBIÉN
¡MIREN!
¡ATIZA! ¡UN COCODRILO!
¡VAMONOS!

¡SUBE!
CORRE!
¡AHÍ VIENE!
¡JA, JA, JA!
ESO LES PASA POR HACER INTERPRETACIONES EN VEZ DE OBSERVAR
SI SE HUBIERAN LIMITADO A UTILIZAR SUS SENTIDOS....
SE HABRÍAN AHORRADO EL SUSTO.
¡ZAS!
¡ANDA!
¡SI ES UN TRONCO...!
¡PUES CLARO!
OTRA VEZ SE HAN EQUIVOCADO: HAY QUE USAR TODOS LOS SENTIDOS, NO HAY QUE INTERPRETAR...
¡DÉJATE! ¡MÁS VALE PREVENIR!
¡CUIDADO, CANÍBALES!
¡HUYAMOS!

¡ESPEREN! ¿POR QUÉ SABEN QUE SON CANÍBALES? SOLO OBSERVAMOS QUE TIENEN LA PIEL OSCURA, ¡LLEVAN VESTIDOS DE COLORES...
¡ESTOS NO HACEN MÁS QUE INTERPRETAR!
¡CORRE, QUE ESTO VA A TERMINAR MAL!
¡A LA MÁQUINA DEL TIEMPO!
GRACIAS A LA MÁQUINA DEL TIEMPO, MINA Y MONCHO VUELVEN AL LABORATORIO. EN LA PANTALLA DE TELEVISIÓN OBSERVAN A SUS COMPAÑEROS.
Y... ¿A VOES LES GUSTA MUCHO LA CARNE...?
¡JA, JA, JA! ¡SOMOS VEGETARIANOS: SÓLO COMEMOS COCOS, DÁTILES, PIÑAS....
¡NO TENEMOS REMEDIO! ¡SIEMPRE NOS EQUIVOCAMOS.
¡SI NO HICIÉRAMOS INTERPRETACIONES!

Para observar es necesario utilizar los sentidos.

No hay que confundir observación con interpretación.

Cuando vamos más allá de lo que nuestros sentidos perciben hacemos interpretaciones.

En la observación debemos usar el mayor número de sentidos posible: vista, oído, tacto, gusto, olfato.

Cuantos más sentidos utilicemos, más completa será la observación.

¿QUÉ ES INFERIR?

LOS NIÑOS ACUDEN A UNA LLAMADA TELEFÓNICA DEL PROFESOR.

EN EL PLATILLO VOLANTE DEL PROFESOR, SE DIRIGEN A LA LUNA

EL PROFESOR LES DICE QUE INFERIR ES DAR UNA EXPLICACIÓN A OBSERVACIONES REALIZADAS.

PUES CLARO. HAS OBSERVADO QUE LA LUNA SE VE DE MAYOR TAMAÑO, QUE LOS CRÁTERES APARECEN CON MÁS CLARIDAD... Y HAS DADO UNA EXPLICACIÓN A ESAS OBSERVACIONES; ES DECIR, HAS HECHO UNA INFERENCIA.
PERO TAMBIÉN PODRÍA SER QUE LA LUNA SE ACERCASE A NOSOTROS. EN ESE CASO, LA INFERENCIA DE MONCHO SERÍA FALSA.
¡ES CIERTO!
JAIME TIENE RAZÓN: UNAS MISMAS OBSERVACIONES PUEDEN EXPLICARSE DE FORMAS DISTINTAS.
¡ES VERDAD! SI VEMOS QUE LA LUNA SE AGRANDA PUEDE SER PORQUE NOS ACERQUEMOS A ELLA O PORQUE ELLA SE NOS VENGA ENCIMA.
SIN EMBARGO, NO TODAS LAS INFERENCIAS SON VERDADERAS. PODEMOS HACER INFERENCIAS FALSAS Y LA ÚNICA MANERA DE SABERLO ES COMPROBÁNDOLAS.
¡YA LLEGAMOS!
AHORA VAN A EXPLORAR UN POCO. OBSERVEN BIEN Y LUEGO HAGAN INFERENCIAS. A VER QUIÉN ACIERTA.
VAMOS POR AQUÍ, MONCHO, A VER SI ENCONTRAMOS ALGÚN LUNÁTICO.
YO VOY A EXPLORAR ESE CRÁTER.

MIRA, MONCHO
¡AHÍ VA! ¡SON PISADAS DE LUNÁTICO!
¡VAMONOS!
¡¡CORRE, MONCHO!!
¡PROFESOR! ¡HAY LUNÁTICOS!
¿LOS HAN VISTO?
NO, PERO HEMOS VISTO SUS PISADAS.
¡AH! ESO ES UNA INFERENCIA: VEN PISADAS E INFIEREN QUE SON DE LUNÁTICO. VAMOS A COMPROBARLA.
EL PROFESOR Y LOS NIÑOS LLEGAN AL LUGAR EN DONDE DESCUBRIERON LAS HUELLAS.
VAMOS A SEGUIRLAS... ¡A VER SI SU INFERENCIA HA SIDO CORRECTA!
¡TENGO MIEDO!
NO SEAS TONTA. ¿QUIÉN TE HA DICHO QUE LOS LUNÁTICOS, SI ES QUE EXISTEN, SON MALA GENTE?

¡MIREN! ¡UNA BANDERA!
VOY A VER COMO ES...
¡ES UNA BANDERA DE LA TIERRA!
ENTONCES LAS PISADAS ERAN DE LOS ASTRONAUTAS QUE LA TRAJERON.
ESA INFERENCIA PARECE VERDADERA...
CREO QUE YA HAN APRENDIDO A INFERIR ¿NO? VAMOS A LA TIERRA; ES HORA DE CENAR.
(ESTOS TERRÍCOLAS ACABARÁN POR DESCUBRIRNOS ALGÚN DÍA.)
(ESO QUE DICES PUEDE SER UNA INFERENCIA FALSA, A LO MEJOR NO SON TERRÍCOLAS.)
FIUU
FIUU
FIUU
FIUU

Inferir es dar una explicación basada en una o varias observaciones.

Toda inferencia debe basarse en observaciones. De lo contrario, será una adivinanza y no una inferencia.

Las inferencias pueden ser verdaderas o falsas.

Para comprobar si una inferencia es verdadera hay que realizar nuevas observaciones; así podremos saber si nos hemos equivocado o no.

¿QUÉ ES PREDECIR?

¿QUÉ VAMOS A HACER HOY, PROFESOR?

POR SER SÁBADO, LES TENGO PREPARADA UNA SORPRESA. VAMOS A EXPLORAR UNA CUEVA SUBMARINA QUE HE DESCUBIERTO HACE UNOS DÍAS.

LO QUE NO ENTIENDO, PROFESOR, ES POR QUÉ SABE QUE HASTA ENTONCES NO LE DARÁ EL SOL.

¡ESTUPENDO! ¿DÓNDE TIENE EL SUBMARINO?

¡UN MOMENTO! TENEMOS QUE ESPERAR HASTA LAS DIEZ Y VEINTICINCO. ¿QUÉ HORA ES, JAIME?

LAS NUEVE Y MEDIA.

¿POR QUÉ HEMOS DE ESPERAR?

MUY SENCILLO: PORQUE HASTA ESA HORA, EL SOL NO ILUMINARÁ LA ENTRADA DE LA CUEVA; Y: BAJÁRAMOS AHORA, NO LA ENCONTRARÍAMOS.

BUENO, ES CUESTIÓN DE SABER PREDECIR. EN EL SUBMARINO LES ENSEÑARÉ A HACER PREDICCIONES. VAMOS A ÉL.

YO TAMBIÉN ME PREGUNTO POR QUÉ SABE QUE A LAS DIEZ Y VEINTICINCO DARÁ EL SOL EN LA ENTRADA DE LA CUEVA.

MIREN: DURANTE CINCO DÍAS HE BAJADO HASTA LA CUEVA Y HE ANOTADO LA HORA EN QUE DABA EL SOL. ESTA ES LA TABLA DONDE ANOTÉ LOS DATOS.

DÍA	HORA
LUNES	10 H. 0 Min.
MARTES	10 H. 5 MIN.
MIÉRCOLES	10 H. 10 MIN.
JUEVES	10 H. 15 MIN.
VIERNES	10 H. 20 MIN.

ESTUDIEN LA TABLA DE DATOS. A VER QUIÉN DESCUBRE LA CLAVE.

¿QUE HAY QUE BAJAR CINCO DÍAS A LA CUEVA...?

¡ANDA! ¡YA LO TENGO! CADA DÍA EL SOL DA EN LA CUEVA CINCO MINUTOS MÁS TARDE QUE EL DÍA ANTERIOR.

¡CLARO! AYER SE ILUMINÓ LA CUEVA A LAS DIEZ Y VEINTE, LUEGO HOY SE ILUMINARÁ A LAS DIEZ Y VEINTICINCO.
¡MIREN! ¡AHÍ ESTÁ LA CUEVA!
¡ES ENORME!
¡QUÉ CURIOSO! EL SOL DA JUSTO EN LA ENTRADA.
¡Y SON LAS DIEZ Y VEINTICINCO EN PUNTO!
¡ES ENORME!
YA LES DIJE QUE MERECÍA LA PENA VISITARLA.
¡VAYA PULPO! ¡ES MAYOR QUE EL SUBMARINO!
¡LAS ALGAS SON PRECIOSAS! Y ESO A PESAR DE QUE LES DA POCO EL SOL.
TENEMOS QUE REGRESAR; ENSEGUIDA SE MARCHARÁ EL SOL.
SI SE LLEGA A ENFADAR EL PULPO, NOS QUEDAMOS SIN SUBMARINO.
ESTA YA APRENDIÓ A HACER PREDICCIONES.
NO, JAIME; ESO QUE HA DICHO MINA ES UNA ADIVINANZA: ELLA NO HA VISTO NUNCA ENFADARSE A UN PULPO.
PROFESOR: A MÍ ME GUSTARÍA SABER PREDECIR. ¿POR QUÉ NO NOS ENSEÑA?

LO PRIMERO QUE SE NECESITA PARA PREDECIR ES HACER OBSERVACIONES.
¡AH! YA VEO POR QUÉ BAJÓ VD. A LA CUEVA CINCO DÍAS SEGUIDOS: ERA PARA OBSERVAR CUÁNDO LE DABA EL SOL.
SÍ, PERO ESO NO ERA SUFICIENTE. ADEMÁS DE OBSERVAR, HAY QUE MEDIR.
¿MEDIR QUÉ?
ESTÁ CLARO: LOS MINUTOS QUE SE RETRASABA EL SOL DE UN DÍA PARA OTRO.
ESTE LO SABE TODO
PARA PREDECIR, PRIMERO HAY QUE OBSERVAR Y MEDIR. NO LO OLVIDEN.
¡YA ESTAMOS LLEGANDO!
¿VOLVEREMOS MAÑANA A LA CUEVA, PROFESOR?
CON UNA CONDICIÓN: QUE PREDIGAN A LA HORA QUE ESTARÁ ILUMINADA.
¡ESO ESTÁ TIRADO! CINCO MINUTOS MÁS TARDE CADA DÍA... ¡A LAS DIEZ Y MEDIA!
¡ESO TAMBIÉN LO SABÍA YO!

PROFESOR, ¿ME DEJA HACER UNA PREDICCIÓN?
NO VAMOS A LLEGAR A TIERRA
EN OTROS VIAJES HE OBSERVADO QUE ESTE SUBMARINO SÓLO TIENE COMBUSTIBLE PARA DOS HORAS; LLEVAMOS DOS HORAS Y CINCO MINUTOS NAVEGANDO...
BUENO, ESO HABRÁ QUE COMPROBARLO...
SE ME OLVIDABA DECIROS QUE TODAS LAS PREDICCIONES HAY QUE COMPROBARLAS PARA VER SI SON CIERTAS.
MORCHO TENÍA RAZÓN, PERO LA COMPROBACIÓN NO ME GUSTA NADA...

Cuando decimos lo que observamos, antes de que se produzca un hecho, realizamos una predicción.

La predicción científica debe estar basada en observaciones y mediciones anteriores.

Sin observaciones y mediciones anteriores, no pueden realizarse predicciones: sólo adivinanzas.

Una predicción puede ser errónea; la única forma de saber si es acertada es comprobarla en la realidad.

APPENDIX C

SCIENCE--A PROCESS APPROACH
PART D, INFERRING 5
THE DISPLACEMENT OF WATER BY AIR (e) (AAAS, 1968)

SCIENCE--A PROCESS APPROACH
PART E, INFERRING 7
INFERRING CONNECTION PATTERNS IN ELECTRIC CIRCUITS
(a) (AAAS, 1968)

INFERRING 5: THE DISPLACEMENT OF WATER BY AIR

OBJECTIVES

At the end of this exercise the child should be able to

1. DISTINGUISH between observation and inferences about the displacement of water by air.
2. CONSTRUCT an inference to explain the movement of liquid out of an inverted container when air moves into it.
3. DESCRIBE observations he can use to test his inferences about the displacement of water by air.

SEQUENCE

Constructing inferences concerning the shape of an object on the basis of observations of transverse, slant and logitudinal sections of the object.

Inferring 8

Describing the expected outcome of future observations based on inferences formulated and tested by the child.

Inferring 7

Describing observations which can be used to test an inference.

THIS EXERCISE

Inferring 5

Demonstrating that inferences may need to be altered on the basis of additional observations.

Inferring 4

RATIONALE

This exercise will give the children further experience in making inferences. In earlier exercises, they have made inferences from their observations of familiar situations. Here, they will make inferences from observations of less familiar phenomena, and they will also test these inferences. As before, the children will be asked to give their reasons for the inferences they make. In this exercise, they may feel very certain that the air pushed the water out of the bottle, but they may not be able to state clearly why they think so. Nevertheless, urge them to try.

Every inference a child makes, no matter how unreasonable it may seem, should be subjected to the same careful analysis. Some children make better inferences than others because they make more observations, keep their observations more clearly in mind, or have a richer store of prior knowledge to draw on. This difference in the ability to infer should be an advantage, since the objectives of this exercise will be satisfied more completely if the children have an opportunity to compare a variety of inferences.

To give the children practice in writing, suggest at the end of each activity that they write one or more inferences based on their observations. If they have difficulty in doing this, let them dictate to you as you write on the board. Have them do their own writing in the Appraisal, however, unless they are very poor at writing.

VOCABULARY

displace	desplazar
displacement	desplazamiento

Materials

Listed below are the materials required to conduct this exercise.

2-liter transparent containers,6
Trays,6
Soft-drink bottles,6
Cardboard, approximately 13 x 24 cm, 1 piece
China marking pencil,1
Food coloring, 1 bottle
Flexible straws, 10
Drinking glass, 1
White paper towel, 1
Seltzer tablets, 2 for each child tested

Introduction Procedure

Introduction. As you work at a table in the front of the room, let the class watch you prepare the apparatus shown in Figure 1 according to the following procedure:

1. Fill one of the transparent containers, which has been placed on a tray, about half full of water.
2. Fill a soft-drink bottle with water and hold a small piece of stiff cardboard, cut from the sheet, firmly over the mouth of the bottle.
3. Invert the bottle and put it mouth downward in the water in the container.
4. Remove the cardboard. The water will not flow from the bottle if the mouth is below the surface of the water in the container.
5. Put several paper drinking straws near the container.

Figure 1

Ask the children if it is possible to get the water out of the bottle without turning the bottle over or pulling it out of the water. Encourage their suggestions and discuss them. Continue to ask for other ideas until someone suggests using one of the drinking straws to blow bubbles of air into the bottle. If interest wanes before the suggestion is made, make it yourself by asking. Could you blow air into the bottle with a straw? ¿Puedes soplar en la botella con el popote?

Activity 1

Set up equipment as you did in the Introduction for each group of five children. Be sure that each child has a straw. Have the children try to blow air bubbles through their straws to get the water out of the bottle. Tell them to make careful observations and to list their observations on the chalkboard. Insist on accurate statements of observations, such as these:

Bubble went up into the bottle.
La espuma de aire subió en la botella.
Some bubbles went up outside the bottle.
Algo de la espuma de aire subió alrededor de la botella.
The water level in the bottle went down.
El nivel del agua en la botella bajó.

Ask the children what they think happened to the water in the bottle. Take time to draw out as many different inferences as possible, and list these on another section of the chalkboard. Be sure the children distinguish clearly between what they actually saw (observations) and what they think was responsible for it (inferences).

They may be sure that air pushed the water out of the bottle. (They may even have learned this previously.) Nevertheless, this view is still an inference and must be tested.

Activity 2

Ask the children how they can test their inferences about what happened to the water that went out of the bottle (in Activity 1) How would you show someone else that the air pushed the water out of the bottle? ¿Cómo le mostrarás a otro que el aire desplazó el agua fuera de la botella? Various tests are possible. A few are described below. Follow the children's suggestions as much as possible. If it is necessary to encourage suggestions, ask questions such as these: Does the level of water in the containers change when you blow air into the bottle? How could you tell? Could you make the water in the bottle look different from the water in the container and watch where it goes when you blow air into the bottle? ¿Cambia el nivel del agua en la bandeja cuando soplas en la botella? ¿Cómo sabes esto? ¿Puedes hacer que el agua en la botella cambie para distinguirla de el agua en la bandeja y notar adonde se va cuando soplas en la botela?

There is a fairly simple way to test the inference that the water flows out of the bottle when the air flows in: Measure the change in water level using the china-marking pencil to mark the water level in the container before and after blowing air into the bottle. Since the bottle must be kept immersed in the water to the same depth while the air is being blown into it, also make a mark on the outside of the bottle and be sure some child in the group holds the bottle so that the mark stays at the water line. To confirm that the rise of the water level in the container is produced by the amount of water in the bottle, the children might empty the container to the first mark, pour water out of the refilled bottle into the container, and see whether the water level reaches the second mark.

A direct and convincing method is to color the water in the bottle, but not the water in the container. If the unstoppered bottle is left inverted in the container for a few minutes before air is blown into it, only a small amount of the color will diffuse into the water in the container. When the air is blown into the inverted bottle, the children can observe that the colored water flows out strongly and mixes with the water in the containers.

INFERRING 7: INFERRING CONNECTION PATTERNS IN ELECTRIC CIRCUITS

OBJECTIVES

At the end of this exercise the child should be able to

1. CONSTRUCT a complete electric circuit consisting of a flashlight cell, a lamp, and two wires.
2. CONSTRUCT inferred connection patterns for hidden circuits.
3. DESCRIBE the expected outcomes of future tests based upon inferred connection patterns.

SEQUENCE

Demonstrating the use of an operational definition to construct a simple electric circuit.

Defining Operationally 1

Constructing a testable inference made by the child about conductors and nonconductors.

Formulating Hypotheses 2

Describing the expected outcomes of future observations based on inferences about electric circuits formulated and tested by the child.

THIS EXERCISE

Inferring 7

Describing observations which can be used to test an inference.

Inferring 5

Describing a sequence of events constituting an inquiry, including purpose, method, materials, procedure, and results.

Communicating 12

Constructing situations to test inferences made by the child.

Inferring 6

RATIONALE

Using the senses to make direct observations is often impossible or unwise. One might learn if electric power is present by placing his finger in an outlet, but using a lamp or a meter is much safer. One might learn if an object is hollow or solid by cutting it apart, but it may be preferable to measure its density or to roll it down an incline. One might learn if two wire ends are connected by physically following along the wires, but it may be preferable to use a battery and a lamp to test whether the wire is continuous. In this exercise children use batteries and lamps to make observations on electric circuits.

Early in the exercise, the children will learn that a lamp (a flashlight bulb) will light if it is part of a closed loop of wires connected to a dry cell. Figure 1 shows this arrangement which is called a closed circuit.

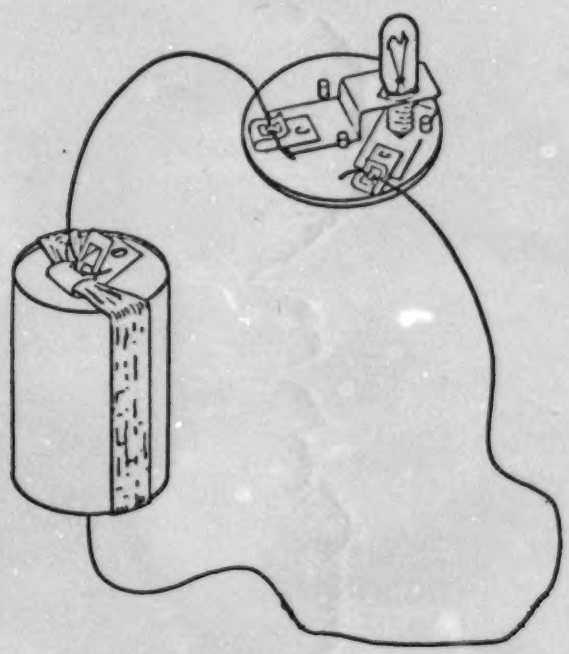

Figure 1

The children use the principle of the closed circuit to determine the pattern of hidden wires in circuit boards. They use a dry cell and lamp circuit, as shown in Figure 2.

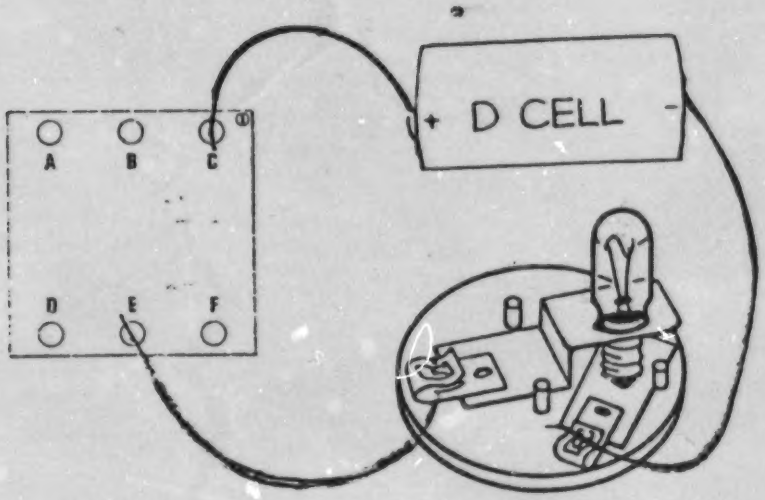

Figure 2

By testing several pairs of wire ends the children (1) infer the connection patterns of the hidden wires, and (2) predict the outcome of further testing on the basis of the inferred patterns. They also discover that an inferred connection pattern may not be the actual wiring pattern and that several inferences may be equally reasonable.

The children can use the materials required for this exercise with complete safety.

VOCABULARY

dry cell
lamp
connection
circuit
closed circuit
open circuit
pattern
insulation

VOCABULARIO

pila seca
globito
conexión
circuito
circuito completo
circuito incompleto
modelo
soquet

MATERIALS

Flashlight dry cells

Number 6 rubber bands

Flashlight lamps and sockets

Insulated wire, 25 cm long

Data sheet (as in Figure 5)

Demonstration circuit boards, 2

Board No. 1 with wiring pattern: A-B, C-D (See .igure 3.)

Board No. 2 with wiring pattern: A-D, B-D

Brass paper fasteners

Data sheet (as in Figure 9)

Sets of eight different circuit boards

Data sheet (as in Figure 12)

Drawings (as in Figure 14)

Round circuit board with five connections

Rectangular circuit board or box with six connections

Data Sheet

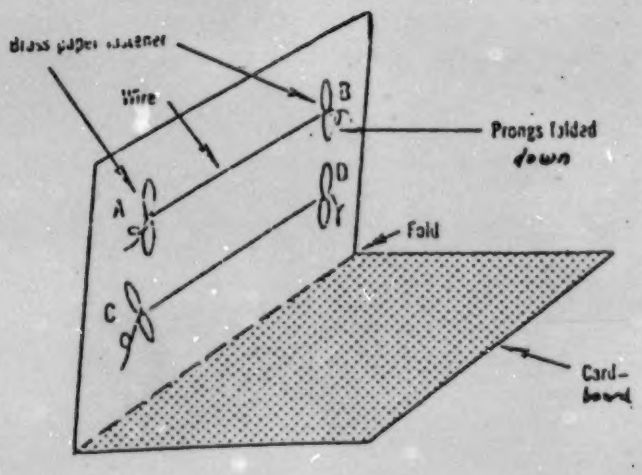

Figure 3

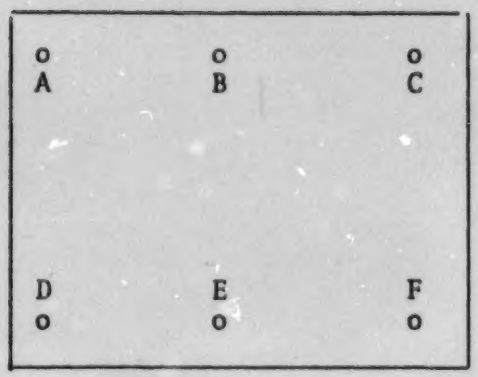

Figure 4

TABLA DE DATO

Construccion de Circuitos Completos

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INSTRUCTIONAL PROCEDURE

Introduction. Give each pair of children one flashlight dry cell in a holder, a flashlight lamp, a lamp socket, and two 25-centimeter pieces of insulated wire with the ends stripped. Identify and name these items for the children if they cannot do it themselves.

Tell the children to assemble the dry cell, lamp, and wires so that the lamp lights. Let them proceed by trial and error, without direction, until they make a closed circuit. The lamp will light to indicate a closed circuit.

Give each child a copy of the data sheet, CONSTRUCTING CLOSED CIRCUITS (See Figure 5). On this, he is instructed to draw the wires as they should be connected to make the lamp light. You should check these as you move from group to group, but let the children keep the data sheets.

Sketch the lamp and the flashlight cell on the chalkboard and ask a child to draw in the wires so that the lamp would light. Have the children describe what is necessary to make the lamp light. What is required is a closed path of wiring that goes from the top of the cell to the lamp and then back to the bottom of the cell. If there is any break in the circuit, the lamp will not glow. Define, or have the children define, "open circuit" and "closed circuit", using the cell, lamp, and wires, and by referring to the diagram on the chalkboard. An open circuit can result from broken wires, poor connections, and a loose or burned-out lamp.

Before you start Activity 1, make sure that all groups have properly operating circuits. The children should be able to state that if the lamp glows, the circuit is closed: if the lamp does not glow, the circuit is open.

Activity 1 - Hidden Connections and the Deomonstration Board

Sketch the circuit shown in Figure 6 on the chalkboard, or give a copy of it to each child. Give each pair of children an additional piece of wire (they should now have a total of three), and ask the children to connect the wires according to the diagram. Ask, Is it a closed circuit? (No.) ¿Es un circuito completo? (No.) How can we make it a closed circuit? ¿Como podemos hacerlo un circuito completo?

The children should quickly suggest putting the two free ends of the wires together. This will make a closed circuit, so that the lamp will light. Ask, Would we have closed circuit if we put a fourth wire between the two free ends? ¿Tendremos circuito completo si añadimos el quarto alambre entre los dos alambres sueltos? Distribute additional pieces of wire and let each pair try making the connection. How about a paper clip? ¿Una prescilla (paper clip)? A pencil? ¿Un lápiz? Let the teams try

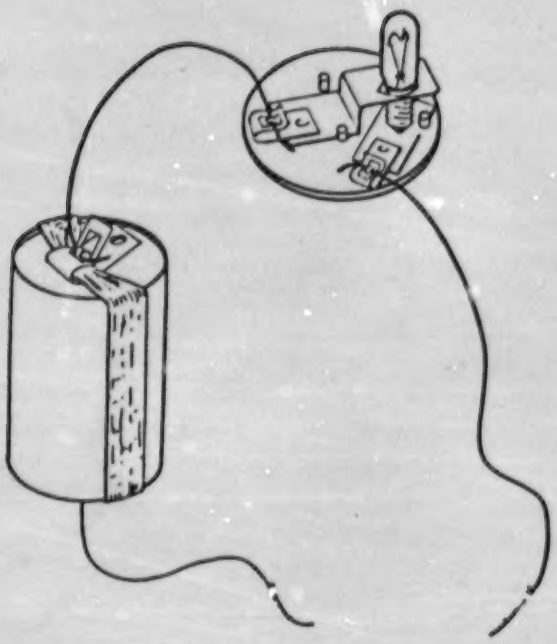

Figure 6

a number of objects that they find about the room. They will discover that they can use some objects to make a closed circuit and not others. However, be sure that they are able to use a wire across the free wire ends to make a closed circuit.

Next, hold two wires in one hand with one end of each wire exposed as shown in Figure 7, but with the other ends concealed and not in contact. In the other hand, conceal a single wire with both ends of the wire exposed as shown in Figure 7. Ask, Can these be used to make a closed circuit? ¿Se pueden utilizar estos para hacer un circuito completo? Although the children may enjoy guessing, they cannot answer your question without trying it. Move about the room, and let two or more teams in turn connect free ends of their circuits to the wires protruding from between your fingers. They will find that their lamps will light when their circuits are connected to the wires in one hand, but not connected to those in the other hand. Ask, What inferences can you make about the wires in my hands? ¿Cuales inferencias puedes hacer acerca de los alambres en las manos? After they have tried to explain their observations, show then the wires within your fists.

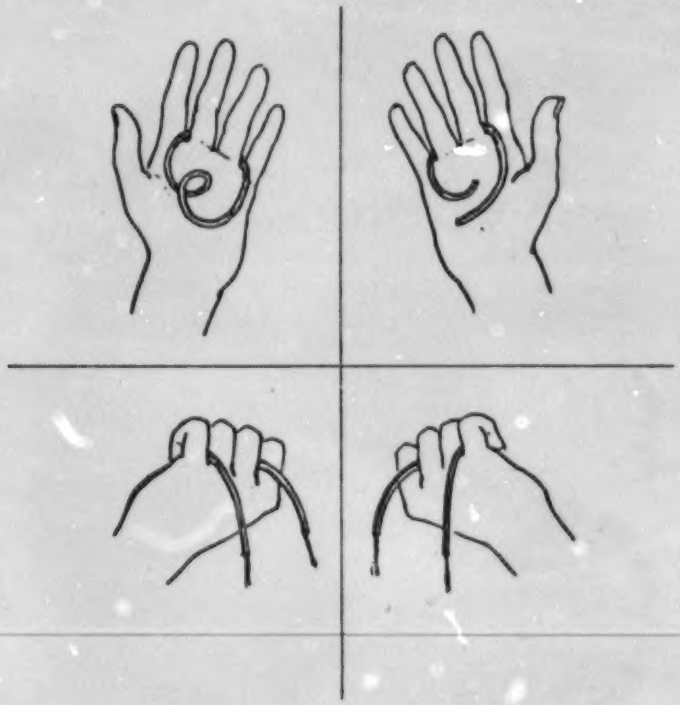

Figure 7

This activity has some interesting variations. Use your judgment about how long you should continue it for your class. You may allow three wires to protrude from between your fingers with all of them connected, none of them connected, or two of them connected. Let different pairs of children test for closed or open circuits and then explain their observations to the rest of the class. At least once, the children should see that two connected wires can be used to make a closed circuit.

Now show the children Demonstration Circuit Board No. 1, which has four exposed paper-fastener heads on the front. Do not let them see the back of the board. Tell them that there are some wire connectors between some of the fastener heads. Ask, Can you infer how the wires are connected between the points you can see? ¿Puedes inferir como están los alambres conectados entre los puntos? The children may say that there is no way to determine this connection pattern without looking at the back of the board; however, several of them should suggest that they use the lamp and the dry cells to see if they can make a closed circuit by connecting any of the points. If you wish, let some children try this with various pairs of connection points on the demonstration board.

Ask the children to name possible pairs of points that could be tested. List these pairs on the chalkboard as the children name them. Arrange the pairs in four columns, which may look like those shown in Figure 8.

A-B	B-A	C-A	D-A
A-C	B-C	C-B	D-B
A-D	B-D	C-D	D-C

Figure 8

During the listing, the children may note that half the pairs are duplicated because A-B and B-A are equivalent. If not, ask, Are some pairs the same? (Yes.) ¿Son lo mismo algunos pares? (Sí.) What are they? ¿Cuales son? (A-B and B-A; A-C and C-A; A-D and D-A; B-C and C-B; B-D and D-B; C-D and D-C.) As the children identify each equivalent pair, cross out one of them. To avoid confusion and to save time, have the children agree on a systematic procedure for testing and recording the observations.

Using the demonstration board, have a pupil test each pair of points remaining on the list. As the class decides whether the circuit is "closed" or "open" in each case, record the observation by writing closed or open beside the label of each pair.

Diagram the front of Demonstration Circuit Board No. 1 on the chalkboard. Next, give a child a piece of white chalk and ask him to draw lines between the connection points that resulted in a closed circuit. Then give a second child some colored chalk. Ask this child to infer a connection pattern, or to indicate how he thinks the wires are connected and to mark the connections on the chalkboard. Is more than one inferred pattern possible? (No.) ¿Es posible inferir más que un modelo? (No.) Were all the pairs tested? (Yes.) ¿Probaron todos los pares? (Sí.) Let the children look inside the demonstration board to see that one wire connects Points A and B and another connects Points C and D.

Activity 2 - Inferring Connection Patterns

In Activity 1, the inferred connection pattern of the wires was the same as the actual connection pattern. The purpose of this next activity is to have the children make observations from which they can infer many different connection patterns. They will then inspect the wiring pattern to see that only one of their inferences is the actual pattern.

Distribute to each child a copy of the data sheet, Inferred Connections. (See Figure 9.) Show the children Demonstration Circuit Board No. 2, and ask them to identify all the possible pairs that can be tested to determine which wire connections behind the board will make a closed circuit. As they identify pairs, they should write in the appropriate letters at the top of each column, as shown in Figure 10. Using a test circuit like the one shown in Figure 6, you, or a child, should test all the pairs. At the same time, the class should record on their data sheets which pairs make open or closed circuits by placing an "X" in the open or closed box under the tested pair, as shown in Fugure 10.

TABLA DE DATO

Conexiones Inferidas

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Ejercicio A TABLA DE DATO Conexiones Inferidas

OBSERVACIONES

Pares	A-B	A-C	A-D	B-C	B-D	C-D
Completo	X		X		X	
Incompleto		X		X		X

Conexciones Inferidas

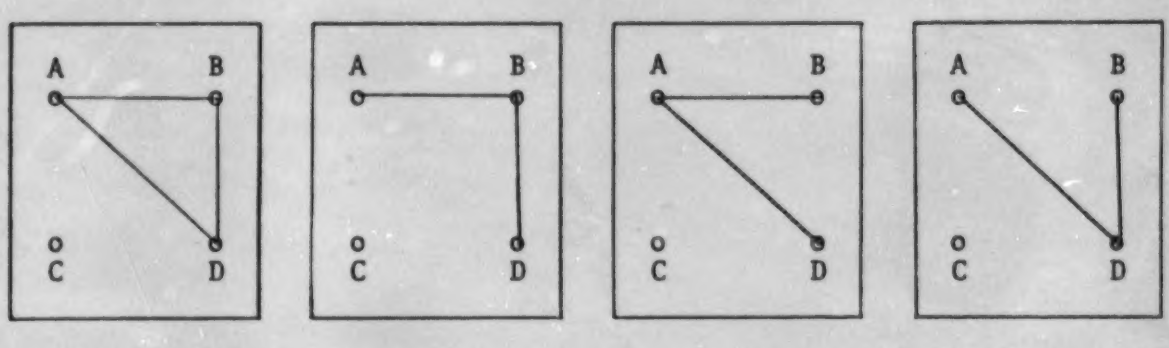

Figure 10

Tell the children to draw lines between pairs of points in the boxes labeled Inferred Connections to show all the possible ways that wires could be connected between the points to result in the observations that they have recorded. As you repeat the instructions, stress that they are inferring wire connection patterns that will explain their observations. You may need to look for examples within the class to demonstrate that the wires might be connected in different ways and yet produce the same observations. The actual pattern cannot be determined unless the board is disassembled and the path of the wires checked. Since four inferred patterns are equally reasonable, the children's completed data sheets should resemble Figure 10.

Remind the class that they can sometimes test inferences by further observation or additional information. In this case, the children can unfold the demonstration board and inspect the wiring pattern to select the correct inference from the four inferences they have made. You should also point out that not all inferences can be checked by observation, and that sometimes they (and scientists) must be content with several equally reasonable inferences.

Activity 3 - Inferring Connection Patterns Among Six Points

Give each pair of children the circuit test equipment shown in Figure 6, two of the eight circuit boards whose wiring patterns are shown below (see Figure 11), and two copies of the data sheet, Infering Connection Patterns Among Six Points. (See Figure 12.)

(1) A-B C-D E-F	(2) A-D B-E C-F	(3) A-B D-F C-E	(4) A-B C-D	(5) A-B-C D-E-F
(6) A-B-D C-F	(7) A-B-C-D-E-F (all connected to one another)		(8) No connections	

Figure 11

TABLA DE DATO

Inferiendo Modelos de
Conexiones Entre Seis Puntos
Tarjeta Numero _____

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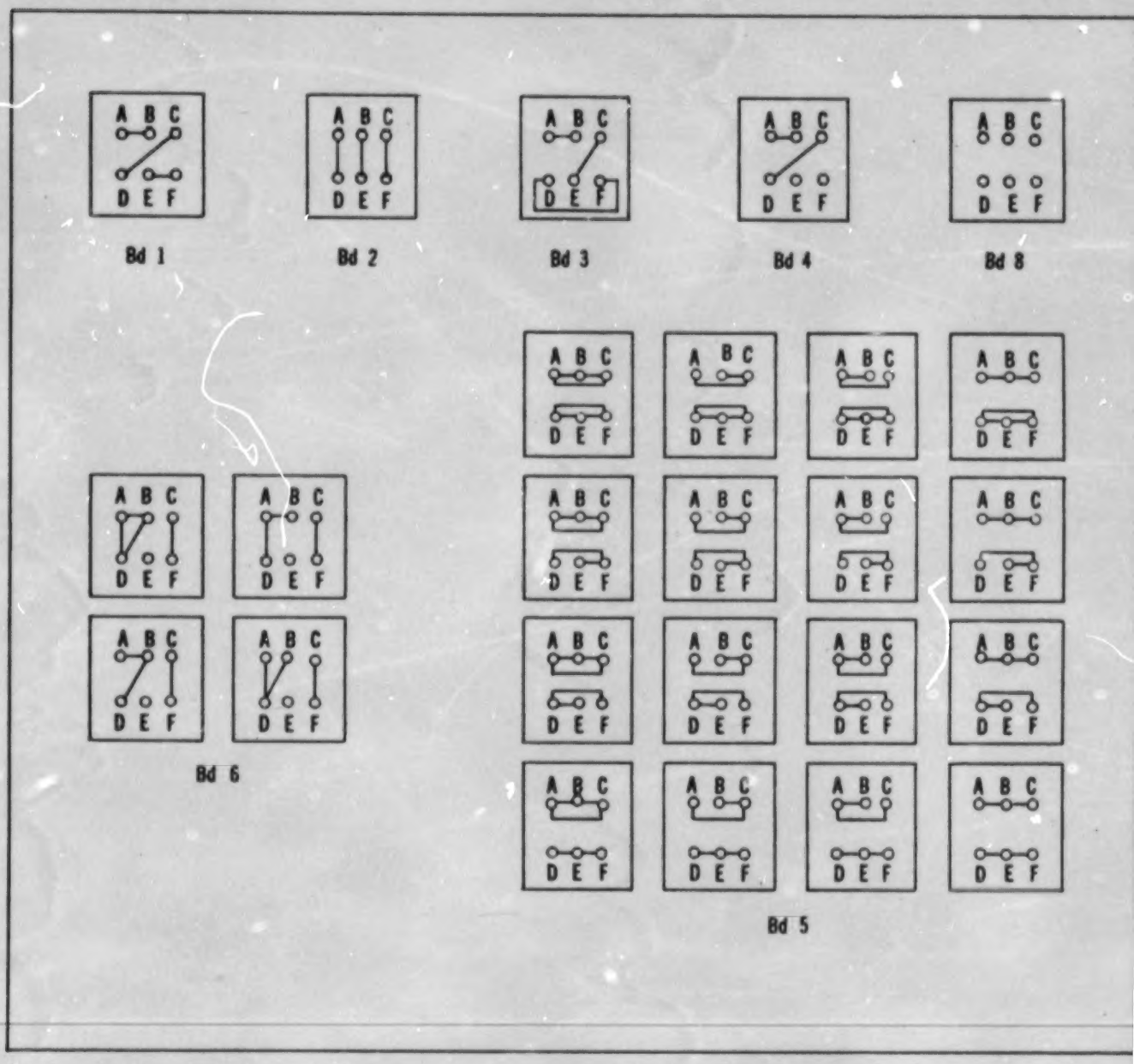


Figure 13

Tell the children to use the dry cell and the lamp circuit to determine which pairs of points can be touched to make a closed circuit. They should identify the number of the board, and record it along with their observation on their data sheets as in Activity 2.

After the children have completed the testing procedure, ask them to infer connection patterns and to sketch possible ways of connecting the wires between the labeled points. Tell them to sketch several connection patterns for any board which could possibly have more than one. Only one inferred connection pattern is possible for Circuit Boards No. 1, 2, 3, 4, and 8. Sixteen inferred patterns are possible for No. 5; four are possible for No. 6. A great many possibilities exist for No. 7.

Figure 13 shows the connection patterns the children should infer, except that one of the many possibilities is shown for Board No. 7

Activity 4 - Expected Outcomes Using Inferred Connection Patterns

Using a drawing on the chalkboard to recall for the class Demonstration Circuit Board No. 2 from Activity 2. With this board, the lamp lit up when the wires of the test circuit were connected to pairs A-B and and A-D. Ask, Would it have been possible to tell before testing further if touching any other pairs would result in a closed circuit? (Yes, B-D.) ¿Hubiera sido posible predecir antes de haber probado más, si tocando otros pares resultaría en un circuito completo? (Sí, B-D.) This is an expected outcome based on an inference. We observe that pair A-B or A-D can be used to make a closed circuit; we infer that since A is connected to both B and D, then B and D are also connected. We can expect the lamp to light when the circuit is connected to Points B and D.

Have the children reconsider their data sheets for the eight circuit boards from Activity 3. Ask, Could you have predicted which pairs would light the lamp before you had tested all the pairs? ¿Hubieras podido predecir cuales pares encendieran el globito antes de probar todos los pares? Give them time to re-examine their observations, and then ask those pairs that studied each of the eight board to give their predictions, if any. They should conclude No for Boards 1, 2, 3, 4, and 8; and Yes for Boards 5, 6, and 7.

Give each child a copy of Figure 14, which lists observations that have been made on four separate imaginary circuit boards (I, II, III and IV) similar to those used in Activity 3. Each board has six connection points, labeled A, B, C, D, E, and F. The lamp of the test circuit lit up when the wires were connected to the pairs of points listed in the second column. Ask the children to examine the observations, and then to make the necessary inferences to predict which additional pairs could be connected to make closed circuits. Have each child record his predictions in the third column of the table, working individually, or with

a classmate.

Board	Connection Pairs Resulting in a Closed Circuit	Pairs That You Predict Can Be Used to Make a Complete Circuit
I	A-C, A-F	
II	A-B, A-D, A-E	
III	A-D, A-E, C-E	
IV	A-B, B-F, C-D, D-F	

Figure 14

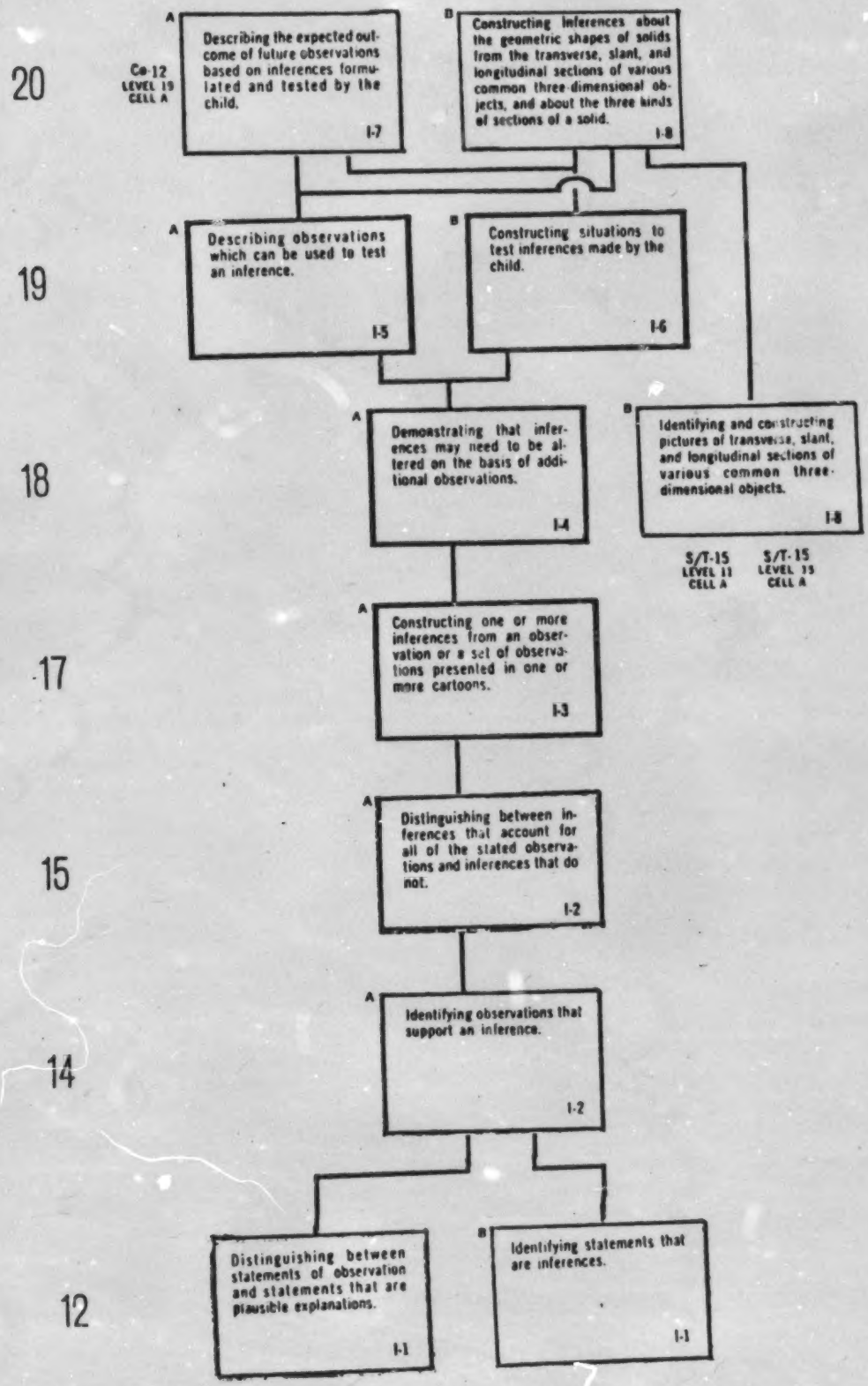
They should suggest these pairs: I (C-F); II (B-D, B-E, D-E); III (A-C, D-E, C-D); and IV (A-C, A-D, A-F, B-C, B-D, C-F).

FIGURA 14

Tarjeta	Conexión de pares resultando en circuito completo	Predice los pares que se hacen circuitos completo
I	A-C, A-F	
II	A-B, A-D, A-E	
III	A-D, A-E, C-E	
IV	A-B, B-F, C-D, D-F	

APPENDIX D

INFERRING HIERARCHY
(AAAS, 1968)


20
19
18
17
15
14
12
A
Co-12
LEVEL 19
CELL A
Describing the expected outcome of future observations based on inferences formulated and tested by the child.
I-7
B
Constructing inferences about the geometric shapes of solids from the transverse, slant, and longitudinal sections of various common three-dimensional objects, and about the three kinds of sections of a solid.
I-8
A
Describing observations which can be used to test an inference.
I-5
B
Constructing situations to test inferences made by the child.
I-6
A
Demonstrating that inferences may need to be altered on the basis of additional observations.
I-4
B
Identifying and constructing pictures of transverse, slant, and longitudinal sections of various common three-dimensional objects.
I-8
S/T-15
LEVEL 11
CELL A
S/T-15
LEVEL 15
CELL A
A
Constructing one or more inferences from an observation or a set of observations presented in one or more cartoons.
I-3
A
Distinguishing between inferences that account for all of the stated observations and inferences that do not.
I-2
A
Identifying observations that support an inference.
I-2
Distinguishing between statements of observation and statements that are plausible explanations.
I-1
B
Identifying statements that are inferences.
I-1

APPENDIX E

INDIVIDUAL COMPETENCY MEASURE FROM
SCIENCE--A PROCESS APPROACH
PART D, INFERRING 5
THE DISPLACEMENT OF WATER BY AIR (e) (AAAS, 1968)

COMPETENCY MEASURE

TASK 1 (OBJECTIVE 2): As the child watches you, invert the wide-mouth bottle, filled with water, in a transparent container containing water, using a piece of cardboard to cover the mouth of the bottle until it is inverted, as described in the Introduction. Say, Watch what happens when I put these two seltzer tablets under the mouth of the jar. Nota lo que pasa cuando pongo ésta pastilla (o píldora) debajo de la botella. Add the tablets. When the bubbling stops ask, What inference can you make to explain why the level of the water in the bottle has gone down? ¿Qué inferencia puedes hacer para explicar por qué bajó el nivel del agua en la botella? Put one check in the acceptable column if the child says that the air or the gas from the bubbles went into the jar and made some of the water go out, or if he offers any other statement that could be considered an explanation.

TASKS 2-4 (OBJECTIVE 1): Say, I am going to read to you some statements I might make about what we have seen here. As I read each statement, tell me whether it is an observation or an inference. Voy a leerles unas declaraciones que puedo hacer acerca de lo que hemos visto aqui. Al leer la declaración dime (o dígame) si es una observación o inferencia.
Task 2): The tablets made the water warm. La pastilla (píldora) calentó el agua. Put one check in the acceptable column for Task 2 if the child says it is an inference.
Task 3): Bubbles rose from the tablets when I put them in the water, and most of them went into the jar. La espuma de la pastilla (o píldora) subió cuando la puse en el agua y casi toda la espuma entró en la botella. Put one check in the acceptable column for Task 3 if he says it is an observation.
Task 4): The bubbles stopped when the tablets couldn't be seen any more. La espuma terminó cuando no se podía ver la pastilla. Put one check in the acceptable column for Task 4 if he says it is an observation.

TASK 5 (OBJECTIVE 3): Say, Tell me how you would test the inference that the tablets made the water warm. You may not taste the liquid. Dime como puedes probar la inferencia que la pastilla (o píldora) calentó el agua. No puedes saborear el liquido. Put one check in the acceptable column if he suggests feeling the water before and after the tablets have been added, or if he suggests putting a thermometer in the water before the tablets are added and watching the thermometer while the bubbling occurs to see if the temperature goes up.

APPENDIX F

INDIVIDUAL COMPETENCY MEASURE FROM SCIENCE--A PROCESS APPROACH PART E INFERRING CONNECTION PATTERNS IN ELECTRIC CIRCUITS (a) (AAAS, 1968)

INDIVIDUAL COMPETENCY MEASURE

(Individual score sheets for each pupil are in the Teacher Drawer.)

TASK 1 (OBJECTIVE 1): Give the child a dry cell, a lamp, a lamp socket, and two wires with bare ends (also a screwdriver, if necessary). Say, **Use the wire to connect the dry cell and lamp so that the lamp lights.**

Acceptable Behavior

For Task 1, the child constructs a closed circuit, and the lamp lights.

TASKS 2-3 (OBJECTIVE 2): Along with the items used in Task 1, give the child another wire, bared at both ends, and a circuit board with hidden wire connections that terminate in five exposed wires or points labeled *J*, *K*, *L*, *M*, and *N*. The hidden wires connect points *M*, *L*, and *N* and also *J* and *K*. Give the child the data sheet, *Inferring Connection Patterns in Electric Circuits*.

Say, **Use the dry cell, lamp, and wires to see which pairs of points can be used to make a closed circuit. Record your observations by placing an "X" in the correct box for each pair you test.**

Acceptable Behavior

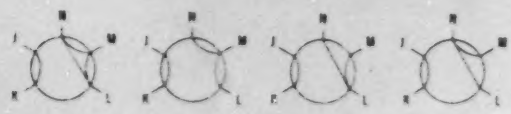
For Task 2, the child correctly assembles the circuit; for Task 3, the child marks pairs N-M, N-L, M-L, and J-K "closed" and all others "open."

If the child has answered correctly, proceed to Task 4. If not, help him as he repeats the observations and corrects his data sheet. Then proceed to Task 4.

TASKS 4-7 (OBJECTIVE 2): Say, **Infer as many connection patterns as you can for the wires inside the circuit board. Draw here** (point to the figures in the second illustration on the data sheet) **all the ways you think the wires might be connected.**

Acceptable Behavior

For Tasks 4-7, the child constructs each of the following circuit patterns in any order:



TASKS 8-13 (OBJECTIVE 3): Give the child a circuit board, or box, with six exposed terminals labeled *K*, *L*, *M*, *N*, *O*, *P*. Points *K*, *L*, *O*, *P* should all be connected. *M* and *N* should be connected. Tell the child, **Use the dry cell and lamp to see if Points K-L can be used to make a closed circuit. Record your observation here.** (Point to Task 8 on the data sheet and let the child carry out your instructions.) **Now see if Points K-P can be used to make a closed circuit. Record your observation.** Allow the child to proceed. **Now see if Points K-O can be used to make a closed circuit. Record your observation.** Let the child proceed.

Acceptable Behavior

For Tasks 8-10, the child marks the "closed" column for the first three pairs.

Ask, **Can you now predict if connecting the test wires to Points P-L will result in a closed circuit?**

Acceptable Behavior

For Task 11, the child says "Yes."

If he responds "Yes," ask, **What is your prediction?**

Acceptable Behavior

For Task 12, the child says connecting the test wires to P-L will result in a closed circuit or that the lamp will light. Let him test his prediction if he wishes.

Ask, **Can you now predict if the lamp will light when the cell and lamp are connected to Points O and N?**

Acceptable Behavior

For Task 13, the child says "No."

Let him make tests and predictions, and inspect the inside of the box or circuit board, if that is possible.

COMPETENCY MEASURE

TASK 1 (OBJECTIVE 1): Give the child a dry cell, a lamp, a lamp socket, and two wires with bare ends (also a screwdriver, if necessary). Say, Use the wire to connect the dry cell and lamp so that the lamp lights. Prende el globito (foco) con los alambres, pila seca, y soquet.

ACCEPTABLE BEHAVIOR

For Task 1, the child constructs a closed circuit, and the lamp lights.

TASKS 2-3 (OBJECTIVE 2): Along with the items used in Task 1, give the child another wire, bared at both ends, and a circuit board with hidden wire connections that terminate in five exposed wires or points labled J, K, L, M, and N. The hidden wires connect points M, L, and N and also J and K. Give the child the data sheet, Inferring Connection Patterns in Electric Circuits. Say, Use the dry cell, lamp and wires to see which pairs of points can be used to make a closed circuit. Record your observations by placing an "X" in the correct box for each pair you test. Usa la pila seca, soquet, y alambres para ver cuales puntos resultan en circuito completo. Apunte (note) sus observaciones con una "X" en el cuadro de cada par que pruebas.

ACCEPTABLE BEHAVIOR

For Task 2, the child correctly assembles the circuit; for Task 3, the child marks pairs N-M, N-L, and J-K "closed" and all others "open."

If the child has answered correctly, proceed to Task 4. If not, help him as he repeats the observations and corrects his data sheet. Then proceed to Task 4.

TASKS 4-7 (OBJECTIVE 2): Say, Infer as many connection patterns as you can for the wires inside the circuit board. Draw here (point to the figures in the second illustration on the data sheet) all the ways you think the wires might be connected. Infiere tantos modelos de conexiones como puedas con los alambres dentro de la tarjeta. Debuja todos los modos en que los alambres están conectados.

ACCEPTABLE BEHAVIOR

For Tasks 4-7, the child constructs each of the following circuit patterns in any order:

TABLA DE DATO

Inferiendo Modelos de
Conexiones en Circuitos Electricos

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TASKS 8-13 (OBJECTIVE 3): Give the child a circuit board, or box, with six exposed terminals labeled K, L, M, N, O, P. Points K, L, O, P should all be connected. M and N should be connected. Tell the child, Use the dry cell and lamp to see if Points K-L can be used to make a closed circuit. Record your observations here. (Point to Task 8 on the data sheet and let the child carry out your instructions.) Usa la pila seca y el soquet para probar si puntos K-L se pueden hacer circuito completo. Note su observación aqui. Now see if points K-P can be used to make a closed circuit. Record your observation. Ahora note si puntos K-P se hacen circuito completo. Apunte su observación. Allow the child to proceed. Now see if points K-O can be used to make a closed circuit. Record your observation. Ahora note si puntos K-O se hacen circuito completo. Apunte su observación. Let the child proceed.

ACCEPTABLE BEHAVIOR

For Tasks 8-10, the child marks the "closed" column for the first three pairs.

Ask, Can you now predict if connecting the test wires to Points P-L will result in a closed circuit? ¿Puedes predecir si conectando puntos P-L resultará en circuito completo?

ACCEPTABLE BEHAVIOR

For Task 11, the child says "Yes."

If he responds "Yes," ask, What is your prediction? ¿Qué es su prediccion?

ACCEPTABLE BEHAVIOR

For Task 12, the child says connecting the test wires to P-L will result in a closed circuit or that the lamp will light. Let him test his prediction if he wishes.

Ask, Can you now predict if the lamp will light when the cell and lamp are connected to Points O and N? ¿Puedes predecir si se prende el globito (foco) cuando se conectan los puntos O y N?

ACCEPTABLE BEHAVIOR

For Task 13, the child says "No."

Let him make tests and predictions, and inspect the inside of the box or circuit board, if that is possible.

APPENDIX G

LANGUAGE PREFERENCE AND ATTITUDE INVENTORY

Las siguientes preguntas o declaraciones son acerca de las actividades en ciencia--actividades en las cuales tú has participado. Con un círculo indica la respuesta más cerca a tu pensamiento. Es importante que indiques con un círculo cuál respuesta está más en acuerdo con tus pensamientos y no con los pensamientos de otra persona.

Número 15 es para tus comentarios. Escribe tus comentarios acerca del idioma hablado en las actividades de ciencia.

1. Creo que las actividades en ciencia que conducimos en clase las dos semanas pasadas fueron:

   A. muy difíciles para comprender

   B. a veces fáciles para comprender y a veces difíciles para comprender

   C. claras y fáciles para comprender

2. Pienso que puedo aprender ciencia mejor cuando se enseña en:

   A. español

   B. inglés

   C. inglés y español

3. El modo que se presentaron las actividades científicas en nuestra clase las últimas semanas fue:

   A. de poco o ningún valor para mí

   B. de algún valor para mí

   C. de mucho valor para mí

4. Yo prefiero que la maestra o maestro hable en:

   A. español

   B. inglés

   C. inglés y español

5. Me gusta hablar:

   A. español en la clase

   B. inglés en la clase

   C. inglés y español en la clase

6. Pienso que debíamos utilizar más:

   A. materiales españoles en clase

   B. materiales ingleses en clase

   c. materiales de las dos lenguas, inglés y español

7. Creo que se debe ofrecer más materias (como aritmética y ciencias naturales) en:

   A. español

   B. inglés

   C. inglés y español

8. El idioma que usó la maestra o maestro para explicar las lecciones científicas:

   A. fue difícil para comprender

   B. a veces la comprendí y a veces no la comprendí

   C. casi siempre la comprendí

9. Creo que la escuela es más interesante cuando:

   A. la maestra o maestro enseña en español

   B. la maestra o maestro enseña en inglés

   C. la maestra o maestro enseña en inglés y español

10. Cuando yo explico algo, lo hago mejor hablando:

    A. español

    B. inglés

    C. inglés y español

11. Pienso que las actividades científicas fueron más interesantes cuando los estudiantes hablaban en:

    A. español

    B. inglés

    C. inglés y español

12. Prefiero que nuestra lección sea conducida en:

    A. español

    B. inglés

    C. inglés y español

13. Si tuviera oportunidad prefería ir a una escuela donde:

    A. se usa solamente español en las clases

    B. se usa solamente inglés en las clases

    C. se usa inglés y español en las clases

14. Pongo atención mejor cuando la instrucción en la clase es en:

    A. español

    B. inglés

    C. inglés y español

15. Tocante al idioma que los maestros usan cuando nos enseñan las lecciones yo quisiera que

The following questions/statements are related to the activities you have participated in the last few weeks. Circle the answer that is closest to the way you feel. It is important that you circle the one you feel is most like your feelings and not those of someone else.

Number fifteen is for your own comments. Write about your feelings concerning the language used in the science activities.

1. I feel the science activities we did in class the last two weeks were:

   A. very difficult for me to understand

   B. sometimes easy for me to understand and sometimes not easy to understand

   C. clear and easy for me to understand

2. I think that I can learn science better when it is taught in:

   A. Spanish

   B. English

   C. Both Spanish and English

3. The way science activities were presented in our class the last two weeks was:

   A. of little or no value for me

   B. of some value to me

   C. of great value to me

4. I feel better when the teacher talks in:

   A. Spanish

   B. English

   C. both Spanish and English

5. I like to speak:

   A. Spanish in class

   B. English in class

   C. both Spanish and English in class

6. I think we should use more:

   A. Spanish materials in class

   B. English materials in class

   C. materials using both the English and Spanish language

7. I think the school should offer more subjects in:

   A. Spanish

   B. English

   C. both Spanish and English

8. The language that the teacher used in explaining our science activities was:

   A. not very understandable

   B. sometimes understandable

   C. almost always clear and understandable

9. I believe school is more interesting when:

   A. the teacher teaches in Spanish

   B. the teacher teaches in English

   C. the teacher teaches in English and Spanish

10. When I explain something I can do it better using:

    A. Spanish

    B. English

    C. Spanish sometimes and English sometimes

11. I think the science activities were more interesting when the students talked in:

    A. Spanish

    B. English

    C. both Spanish and English

12. I feel better when our lessons are in:

    A. Spanish

    B. English

    C. both Spanish and English

13. If I had my choice I would go to a school where:

    A. only Spanish is used in the classroom

    B. only English is used in the classroom

    C. both Spanish and English are used in the classroom

14. I am able to pay attention better to the classwork when the instruction is in:

    A. Spanish

    B. English

    C. both Spanish and English

15. With regard to the language used by the teachers in the teaching of lessons in our school I wish

APPENDIX H

RAW SCORES ON FIRST AND SECOND COMPETENCY MEASURES

RAW SCORES
ON FIRST COMPETENCY MEASURE

	Treatment Group I	Treatment Group II	Treatment Group III	Treatment Group IV
School A	5	3	4	4
	5	4	3	5
	5	5	5	5
	5	5	5	4
	5	2	5	4
	4	4	3	
School B	5	5	3	5
	5	5	4	5
	4	5	3	4
	4	5	5	5
	4	4	5	4
	4	5	4	5
			5	5
School C	4	5	4	4
	5	4	5	4
	5	5	5	4
	4	5	4	4
	5	1	5	5
	5	5	5	5
School D	5	5	4	5
	5	5	4	3
	5	5	4	4
	4	4	4	4
	3	5	5	5
	5	5	5	4
	5	5	5	4
		4	4	4

RAW SCORES
ON SECOND COMPETENCY MEASURE

		Treatment Group I	Treatment Group II	Treatment Group III	Treatment Group IV
School A		12	12	12	11
		11	10	10	10
		10	9	9	9
		10	7	8	7
		9			7
	Sum	61	39	38	44
	$\bar{X}$	10.167	9.500	9.750	8.800
	S^2	1.37	4.33	2.9	3.2
	S	1.169	2.082	1.708	1.789
School B		13	13	13	13
		13	13	13	13
		13	13	13	13
		13	13	13	13
		13	13	12	13
		13	12		13
	Sum	78	77	64	78
	$\bar{X}$	13.000	12.833	12.800	13.000
	S^2	0.000	0.17	0.20	0.000
	S	0.000	0.408	0.447	0.000
School C		13	13	13	13
		13	12	13	12
		13	12	12	12
		12	12	11	12
		12	12	11	12
		11		6	12
	Sum	74	61	66	73
	$\bar{X}$	12.333	12.200	11.000	12.167
	S^2	0.67	0.20	6.8	0.17
	S	0.817	0.447	2.608	0.408

		Treatment Group I	Treatment Group II	Treatment Group III	Treatment Group IV
School D		13	13	13	13
		13	13	13	13
		12	13	13	13
		12	13	12	12
		12	12	12	12
		11	12	12	12
			12	12	12
			12	12	
	Sum	73	100	99	87
	$\bar{X}$	12.167	12.500	12.375	12.429
	S^2	0.57	0.29	0.26	0.29
	S	0.753	0.535	0.518	0.535

APPENDIX I

QUESTION ANALYSIS ON LANGUAGE PREFERENCE AND ATTITUDE INVENTORY

Question 1. I feel the science activities we did in class the last two weeks were:

A. Very difficult for me to understand
B. Sometimes easy for me to understand and sometimes not easy to under stand
C. Clear and easy for me to understand

Pregunta 1. Creo que las actividades en cienca que conducimos en clase las dos semanas pasadas fueron:

A. Muy difícil para comprender
B. A veces faciles para comprender y a veces difíciles para comprender
C. Claras y fáciles para comprender

As indicated in Table 7, of 101 respondents 7 percent selected A, 57 percent selected B and 36 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level B was preferred over A and C.

Question 2. I think that I can learn science better when it is taught in:

A. Spanish
B. English
C. Both Spanish and English

Pregunta 2. Pienso que puedo aprender ciencia mejor cuando se enseña en:

A. español
B. inglés
C. inglés y español

As indicated in Table 7, of 101 respondents 7 percent selected A, 31 percent selected B and 62 percent selected C. In the test of significance, there was a difference between A and B, A ard C, B and C. At the .05 level C was preferred over A and B.

Question 3. The way science activities were presented in our class the last two weeks was:

A. of little or no value for me
B. of some value to me
C. of great value to me

Pregunta 3. El modo que se presentaron las actividades científicas en nuestra clase las últimas semanas fue:

A. de poco o nigún valor para mí
B. de algún valor para mí
C. de mucho valor para mí

As indicated in Table 7, of 101 respondents 3 percent selected A, 20 percent selected B and 77 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 4. I feel better when the teacher talks in:

A. Spanish
B. English
C. both Spanish and English

Pregunta 4. Yo prefiero que la maestra o maestro hable en:

A. español
B. inglés
C. inglés y español

As indicated in Table 7, of 101 respondents 7 percent selected A, 24 percent selected B and 69 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 5. I like to speak:

A. Spanish in class
B. English in class
C. both Spanish and English in class

Pregunta 5. Me gusta hablar:

A. español en la clase
B. inglés en la clase
C. inglés y español en la clase

As indicated in Table 7, of 101 respondents 7 percent selected A, 30 percent selected B and 63 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 6. I think we should use more:

A. Spanish material in class
B. English material in class
C. materials using both the English and Spanish language

Pregunta 6. Pienso que debiamos utilizar más:

A. materiales españoles en clase
B. materiales ingleses en clase
C. materiales de las dos lenguas, inglés y español

As indicated in Table 7, of 101 respondents 8 percent selected A, 14 percent selected B and 78 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 7. I think the school should offer more subjects in:

A. Spanish
B. English
C. both Spanish and English

Pregunta 7. Creo que se debe ofrecer más materia (como aritmética y ciencias naturales) en:

A. español
B. inglés
C. inglés y español

As indicated in Table 7, of 101 respondents 11 percent selected A, 18 percent selected B and 71 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 8. The language that the teacher used in explaining our science activities was:

A. not very understandable
B. sometimes understandable
C. almost always clear and understandable

Pregunta 8. El idioma que usó la maestra o maestro para explicar las lecciones científicas:

A. fue difícil para comprender
B. aveces la comprendí y a veces no la comprendí
C. casi siempre la comprendí

As indicated in Table 7, of 101 respondents 5 percent selected A, 33 percent selected B and 62 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 9. I believe school is more interesting when:

A. the teacher teaches in Spanish
B. the teacher teaches in English
B. the teacher teaches in English and Spanish

Pregunta 9. Creo que la escuela es más interesante cuando:

A. la maestra o maestro enseña en español
B. la maestra o maestro enseña en inglés
C. la maestra or maestro enseña en inglés y español

As indicated in Table 7, of 101 respondents 12 percent selected A, 8 percent selected B and 80 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 10. When I explain something I can do it better using:

A. Spanish
B. English
C. Spanish sometimes and English sometimes

Pregunta 10. Cuando yo explico algo, lo hago mejor hablando:

A. español
B. inglés
C. inglés y español

As indicated in Table 7, of 101 respondents 18 percent selected A, 44 percent selected B and 39 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level, B was preferred over C.

Question 11. I think the science activities were more interesting when the students talked in:

A. Spanish
B. English
C. both Spanish and English

Pregunta 11. Pienso que las actividades científicas fueron más interesantes cuando los estudiantes hablaban en:

A. español
B. inglés
C. inglés y español

As indicated in Table 7, of 101 respondents 14 percent selected A, 26 percent selected B and 60 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 12. I feel better when our lessons are in:

A. Spanish
B. English
C. both Spanish and English

Pregunta 12. Prefiero que nuestra lección sea conducida en:

A. español
B. inglés
C. inglés y español

As indicated in Table 7, of 101 respondents 11 percent selected A, 31 percent selected B and 58 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 13. If I had my choice I would go to a school where:

A. only Spanish is used in the classroom
B. only English is used in the classroom
C. both English and Spanish are used in the classroom

Pregunta 13. Si tuviera oportunidad prefería ir a una escuela donde:

A. se usa solamente español en las clases
B. se usa solamente inglés en las clases
C. se usa inglés y español en las clases

As indicated in Table 7, of 101 respondents 5 percent selected A, 12 percent selected B and 83 percent selected C. In the test of

significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

Question 14. I am able to pay attention better to the classwork when the instruction is in:

A. Spanish
B. English
C. both Spanish and English

Pregunta 14. Pongo atención mejor cuando la instrucción en la clase es en:

A. español
B. inglés
C. inglés y español

As indicated in Table 7, of 101 respondents 10 percent selected A, 31 percent selected B and 59 percent selected C. In the test of significance, there was a difference between A and B, A and C, B and C. At the .05 level C was preferred over A and B.

VITA

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